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ORIGINAL ARTICLES.

I.—A Collection of Egyptian Fossil Madreporaria.

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(PLATES VIII AND IX.)

THE collection of fossils belonging to the Geological Survey of Egypt which has been sent to England for description by Capt. H. G. Lyons, R.E., contains a series of forty specimens of corals, including representatives of nine genera and eleven species. Of the latter two are new.

The horizons represented are as follows :—

Pleistocene: Raised coral reefs at Jebel Zait.
Middle Miocene—Helvetian: Camps 8 and 20 between Cairo and Suez; near Jebel Attaka, Jebel Owebid, etc.
Upper Eocene: Fayum, in Lake Birket-el-Qurun.
Lower Eocene—Libyan: Dungul Wells and near Silsila, Upper Egypt.
Turonian: Abu Roasch, west of Gizeh.

A record of a species of *Fungia* from the Pleistocene deposits, based on some specimens in the British Museum collection, is included in the present paper.

The principal works on the Egyptian coral-faunas are the following :—

C. G. Ehrenberg. "Beiträge zur physiologischen Kenntniss der Corallenthiere im Allgemeinen, und besonders des rothen Meeres, nebst einem Versuche zur physiologischen Systematik derselben": Abh. k. Akad. Wiss. Berlin f. 1832 (1834), pp. 225–380.

C. B. Klunzinger. "Die Korallthiere des rothen Meeres," pts. ii and iii. Berlin, 1879.

Joh. Felix. "Korallen aus ägyptischen Tertiärbildungen": Zeit. deut. geol. Ges., vol. xxxvi (1884), pp. 415–453, pls. iii–v.

E. Pratz. "Eocäne Korallen aus der lybischen Wüste und Aegypten": Beitr. Geol. Pal. libysch. Wüste, pt. ii (1883), pp. 219–238, pl. xxxv.

Th. Fuchs. "Beiträge zur Kenntniss der Miocänfauna Aegyptens und der libyschen Wüste": Beitr. Geol. Pal. libysch. Wüste, pt. ii (1883), pp. 18–66, pls. vi–xxii.

K. Mayer-Eymar. "Die Versteinerungen der tertiären Schichten von der westlichen Insel im Birket-el-Qurûn See": ibid., pt. ii (1883), pp. 67–78, pl. xxiii.

I. PLEISTOCENE.

Genus SYMPHYLLIA (Edwards & Haime), 1848.

SYMPHYLLIA ERYTHRACEA? (Klunzinger), 1879.

Isophyllia erythracea? Klunzinger, 1879: "Korallthiere roth. Meer.," pt. III, Die Steinkorallen, (II) Asträaceen und Fungiaceen, p. 10, pl. i, fig. 10; pl. ix, fig. 9.

DISTRIBUTION.—Recent: Red Sea (Klunzinger). Pleistocene: Raised reef at Jebel Zait; Coll. Geol. Surv. Egypt, No. 632.

REMARKS.—The collection includes a fossil which is probably the cast of a massive *Symphyllia*, and agrees more closely in general appearance with *Symphyllia erythracea* than with any other species. The specimen is not in a condition for positive determination. Walther[1] has figured a coral from the raised reefs of Jebel Hamman Musa on the coast of the Gulf of Suez, opposite the locality whence the Egyptian Survey specimen was obtained, which probably also belongs to this species.

Pourtalès[2] and Duncan[3] have both urged that *Isophyllia* and *Symphyllia* should be merged, a proposal with which I agree: this species is therefore included in *Symphyllia*, as that name has three years' priority.

Genus ORBICELLA, Dana, 1848.

ORBICELLA FORSKALI (Edwards & Haime), 1849.

Astræa Forskaliana, Edwards & Haime, 1849, "Mon. Astr." No. 4, pt. 3: Ann. Sci. nat., Zool., ser. 3, vol. xii, p. 100.

? *Favia tubulifera*, pars, Klunzinger, 1879: op. cit., p. 28, pl. x, fig. 2 (*non* pl. iii, fig. 6).

Orbicella mammillosa, Klunzinger, 1879: ibid., p. 49, pl. v, fig. 5; pl. x, fig. 10.

DISTRIBUTION.—Recent: Red Sea. Pleistocene: Low-level reefs of Jebel Zait, Egypt; Coll. Geol. Surv. Egypt, No. 22. High-level reefs (150 metres), near Jebel Zait; Coll. Geol. Surv. Egypt, No. 373.

The collection of Pleistocene corals from the shores of the Gulf of Suez includes four specimens of *Orbicella*, which I refer to

[1] J. Walther, "Die Korallenriffe der Sinaihalbinsel": Abh. k. säch. Ges. Wiss., vol. xxiv (1888), pl. v, fig. 9.

[2] L. F. de Pourtalès, "Deep-Sea Corals": Ill. Cat. Mus. Comp. Zool., No. iv (1871), p. 70.

[3] P. M. Duncan, "Revision of Madreporaria": Journ. Linn. Soc., Zool., vol. xviii (1884), p. 91.

Orbicella Forskali (Ed. & H.). This determination, I feel sure, is not free from doubt, as I have not been able to see specimens of the four following recent "species"—*Orbicella Forskali* (Ed. & H.), *O. laxa*, Klnz., *O. mammillosa*, Klnz., and *Favia tubulosa*, Klnz.

The specimens agree in every essential character with the original diagnosis of *Orbicella Forskali*. That coral was then said to have septa belonging to the fourth cycle, which was not, however, stated to be complete. The four fossil specimens have three complete cycles of septa and representatives of the fourth. The only difference between the corals and the original description of *O. Forskali* is, that the columella is more strongly developed, which, however, is not an important character in *Orbicella*. But in the "Histoire Naturelle des Coralliaires," Milne Edwards and Haime put *Orbicella Forskali* into the group of species having four complete cycles. This was probably an error, and possibly a mere accident. Klunzinger had not seen specimens of the species, but he accepted the presence of four complete cycles from Milne Edwards and Haime's action in 1857, and founded for an allied coral with the fourth cycle incomplete the species *O. mammillosa*.

The coral, however, among Klunzinger's series with which these Pleistocene specimens most closely agree is *Favia tubulifera*, Klnz. Klunzinger gave two figures of this species, pl. iii, fig. 6, and pl. x, fig. 2, the characters of which do not seem to me quite consistent. The former is a true *Favia*: the corallites are irregular, triangular or elongated, and in one case, at least, is clearly undergoing fission. But the latter specimen (pl. x, fig. 2) shows only the characters of *Orbicella*; that may be due to the fact that the specimen figured is small; but as far as that figure goes the specimen appears to be specifically identical with *Orbicella Forskali*.

Faurot[1] has recorded this species from the Pleistocene deposits of the southern end of the Red Sea in the Gulf of Tadjura.

Favia denticulata (Ell. & Sol.) has corallites somewhat of the same type as regards numbers of septa, development of columella, and size; but the calice is very much deeper, and the septa thinner and more equal in size.

Genus FUNGIA, Lamarck, 1801.

Fungia patella (Ell. & Sol.), 1786.

Var. lobulata, Klunzinger, 1879.[2]

The British Museum collection includes three small specimens (R. 1,308) of *Fungia* from the Egyptian Pleistocenes, which may be conveniently recorded here. The specimens are young, having the following dimensions:—

	Height.			Diameter.
(*a*)	12 mm.	...	...	30 by 35 mm.
(*b*)	9 mm.	...	...	30 by 33 mm.
(*c*)	7 mm.	...	...	33 by 37 mm.

[1] L. Faurot, "Une Mission dans la Mer Rouge (Île de Kamarane) et dans le Golfe d'Aden (Aden et Golfe de Tadjoura)": Arch. Zool. Exper., ser. 2, vol. vi, p. 121.

[2] Klunzinger, op. cit., p. 62, pl. vii, fig. 4; pl. viii, fig. 2.

The form varies considerably: the base is concave in *a*, but convex in *b*, and flat in *c*; the shape of *a* is somewhat reniform, but *b* and *c* have irregular marginal lobes.

The specimens present remarkable resemblances to *F. repanda*, Dana,[1] with which they agree in general form, in the depression round the corallum, half-way between the centre and margin, in the small number and thickness of the septa, and in the proportions of the calicular fossa; but the under surface is not coarsely papillose, and the septal teeth are not turned backwards (see Pl. IX, Fig. 5), though this character may have been destroyed by weathering.

The resemblance to *F. repanda* necessitates a comparison of these corals with *F. scruposa*, Klnz.,[2] which agrees with these specimens in the prominence of the expanded inner ends of the septa; but that species, like *F. repanda*, differs by the characters of the costæ, which are coarsely and abundantly dentate. *F. valida*, Verr.,[3] which Klunzinger has figured from the Red Sea, agrees in its septal characters, but differs by the great inequality of the costæ.

Klunzinger has doubtfully included Verrill's *F. Haimei*[4] as a synonym of his *F. patella* var. *lobulata*. But Verrill states that *F. Haimei* differs from *F. discus* by having on its nearly equal costæ numerous sharp curved spines, instead of irregularly scattered obtuse spines. In this respect the three Egyptian specimens differ from *F. Haimei*, as they have low, blunt, scattered spines on the costæ (Pl. IX, Fig. 5). Their general characters, however, agree so closely with those of *F. patella* that they may be safely included in that species as members of the variety *lobulata*.

II. MIOCENE.

Genus STYLOPHORA, Schweigger, 1819.

Stylophora asymmetrica, nov.

Diagnosis.

Corallum massive, flat-topped, growing in successive horizontal laminæ. The upper surface is ornamented by the long, sharp, well-raised septo-costæ.

Corallites very large, separated by exothecal areas slightly narrower than the diameter of the corallites.

Calices rarely deep; usually small and raised above the general surface of the corallum. The calices rest on the flat-topped columella, and are bounded laterally by the highly raised, exsert septa.

Septa irregular in development. There are typically six large, thick primary septa fused to the columella, and six short secondary septa, of which the inner margin is free. But this diagrammatic

[1] Dana, "Zooph. Explor. Exped. Wilkes," vol. viii (1848), p. 295, pl. xix, figs. 1–3.
[2] Klunzinger, op. cit., p. 63, pl. vii, fig. 2; pl. viii, fig. 1.
[3] Verrill, "List of Polyps": Bull. Mus. Comp. Zool., vol. i (1864), p. 51.
[4] Verrill, op. cit., p. 51.

arrangement is seldom seen. There are usually three primary septa on one side and four or five on the other; the septa are rarely bilaterally symmetrical, and the arrangement is heptameral or octameral, rather than hexameral. Primary septa highly exsert.

Columella, massive, flat-topped.

DIMENSIONS.

Horizontal laminæ	5 in 12 mm.
Average diameter of corallite	6·5 mm.
Average distance of calicinal centres	11 mm.

DISTRIBUTION.—Middle Miocene—Helvetian: Egypt, east side of Wadi Jiaffra, north-east of Caravanserai No. 8, on road from Cairo to Suez; Coll. Geol. Surv. Egypt, No. 644.

DESCRIPTION OF FIGURES.—Pl. VIII, Fig. 4*a*, part of upper surface of a corallum, nat. size; Fig. 4*c*, side view of the same specimen, showing lamellar growth, nat. size; Fig. 4*b*, one corallite, × 2 diam.

AFFINITIES.—In Duncan's diagnosis of *Stylophora* he states that "the calices are rather deep," as is the case in the type species, *S. digitata* (Pall.), and the characteristic forms of the genus. The two corallites of *S. similis* (May.-Eym.) figured as Pl. VIII, Fig. 6, are typical forms of the Eocene group of *Stylophoræ*, which agree closely with the recent species. Another series of species is, however, included in the genus which have larger corallites and raised, exsert septa. *S. asymmetrica* is the extreme form of this group, and I felt at first that it ought to be placed in a new genus. But the essential characters are those of the true *Stylophora*; the difference is due to the much greater size of the corallites, and to the fact that the calice appears superficial, as it is usually raised on the exsert septa. But the calice is really deep, as it occupies a depression surrounded by the raised septa; and in some corallites the septa end below the surface of the corallum.

The nearest ally of this species is probably *S. macrotheca*, Ach.,[1] in which, however, the corallites are much smaller, the distance between the calicinal centres being only from 2·5 to 3 mm., so that they are about a quarter of the size of those of *S. asymmetrica*.

Another coral which presents some striking resemblances is *S. subreticulata*, Reuss,[2] a well-known Helvetian species from the Oberer Tegel of Grund. The Egyptian coral differs, however, by the greater size of the corallites, by the greater prominence of the secondary septa, and by the asymmetry of the septa. The costæ occur, moreover, as raised lines, whereas in *S. subreticulata* the exotheca is ornamented by radial series of coarse granules.

From the typical Oligocene set of species, e.g., *S. distans* (Leym.),[3]

[1] A. d'Achiardi, "Cor. Eoc. Fruili," pt. iii: Atti Soc. tosc. Sci. nat., vol. i (1875), p. 178, pl. xiv, fig. 2.

[2] A. E. von Reuss, "Foss. Kor. öster.-ung.-Mioc.": Denk. Akad. Wiss. Wien, vol. xxxi (1871), p. 250, pl. v, fig. 10; pl. vii, fig. 1; pl. xiii, fig. 5. The secondary septa are shown only in pl. vii, fig. 1*b*.

[3] A. Leymerie, "Mém. Terr. à Nummul. Corbières": Mém. Soc. géol. France, ser. 2, vol. i (1844), p. 358, pl. xiii, fig. 6. Also Von Reuss, "Pal. Stud. ält. Tert. Alpen": Denk. Akad. Wiss. Wien, vol. xxviii (1868), p. 24, pl. ix, fig. 2.

S. conferta, Reuss,[1] *S. tuberosa* (Cat.),[2] *S. annulata*, Reuss,[3] and *S. pulcherrima*, Ach.,[4] this new species may be easily distinguished, as they have plain inter-calicular areas, and the calices surrounded by a small raised rim. *S. confusa*, Dunc.,[5] from the Gaj Series (Miocene) of Sind, differs by its very crowded corallites.

Genus ORBICELLA, Dana, 1848.

Orbicella Schweinfurthi (Felix), 1884.

Heliastræa Schweinfurthi, Felix, 1884, "Kor. ägypt. Tert.": Zeit. deut. geol. Ges., vol. xxxvi, p. 449, pl. v, fig. 5.

Distribution.—Middle Miocene — Helvetian: Wadi Ramlieh (Felix); near north side of Jebel Attaka, near Suez; Coll. Geol. Surv. Egypt, Nos. 997 and 999.

Figure.—Pl. IX, Fig. 3, part of a horizontal section, × 3 diam.

Affinities.—One of the four specimens of this coral resembles *Orbicella Guettardi* (Defr.),[6] and may represent the fossil recorded from Egypt by Fuchs[7] as *Heliastræa* cf. *Rochettana*. It is certainly very similar to the figures of that species given by D'Achiardi.[8] Felix's species is an ally of *O. Defrancei* (Ed. & H.),[9] but the calices are deeper.

Genus PLESIASTRÆA, Edwards & Haime, 1848.

Plesiastræa microcalyx (Felix), 1884.

Heliastræa microcalyx, Felix, 1884: op. cit., p. 450, pl. v, fig. 4.

Distribution.—Middle Miocene — Helvetian: Wadi Ramlieh (Felix). Between lat. 30° 16′ 40″ and 30° 15′ 50″, and long. 31° 54′ 40″ and 32° 2′ 10″; Coll. Geol. Surv. Egypt, No. 814.

Description of Figures.—Pl. VIII, Fig. 5*a*, part of upper surface of an encrusting corallum, × 2 diam.; Fig. 5*b*, horizontal section across the same specimen, × 4 diam.

Affinities.—This coral agrees exactly in external form with Felix's figure, so that I feel no doubt as to their specific identity. The coral has not the external aspect of an *Orbicella*, and I was

[1] Von Reuss, ibid., p. 25, pl. ix, figs. 3–6.

[2] T. A. Catullo, "Terr. Sedim. Sup. Venezie" (1856), p. 63, pl. xiv, fig. 3; and Von Reuss, op. cit., p. 46, pl. ix, fig. 7.

[3] Von Reuss, "Foram. Anth. Bry. Oberburg": Denk. Akad. Wiss. Wien, vol. xxiii (1864), p. 12, pl. ii, figs. 1–3.

[4] A. d'Achiardi, "Cor. Eoc. Fruili," pt. iii: Atti Soc. tosc. Sci. nat., vol. i (1875), p. 176, pl. xiii, figs. 1–11. P. M. Duncan, "Foss. Cor. Sind": Pal. Indica, ser. xiv, pt. 1 (1880), p. 73, pl. xv, figs. 12, 13.

[5] Duncan, ibid., p. 83, pl. xxiii, fig. 7.

[6] Vide Michelin, "Icon. Zooph." (1842), p. 58, pl. xii, fig. 3.

[7] Th. Fuchs, "Beitr. Kenntn. Mioc. fauna Aegypt.": Beitr. Geol. libysch. Wüste, vol. iii (1883), p. 65.

[8] A. d'Achiardi, "Studio Comp. Cor. Terr. terz. Piem. e Alpi Venete": Annali Univ. Pisa, vol. x (1868), p. 14, pl. i, figs. 12, 13.

[9] Vide Von Reuss, "Foss. Kor. öster.-ung. Mioc.": Denk. Akad. Wiss. Wien, vol. xxxi (1871), p. 239, pl. ix, fig. 3; pl. x, fig. 1.

not surprised that a microscopic section showed the presence of pali, and accordingly necessitated the transference of the species to *Plesiastræa*. The figure of the section also illustrates the nature of the exotheca.

The species is very closely allied to *Plesiastræa Romettensis*, Seg.[1]

Genus SOLENASTRÆA, Edwards & Haime, 1848.

Solenastræa Turonensis (Michelin), 1847.

Astræa Turonensis, Michelin, 1847: "Icon. Zooph.," p. 312, pl. lxxv, figs. 1, 2.

Solenastræa Turonensis, Edwards & Haime, 1857: "Hist. nat. Cor.," vol. ii, p. 498.

Distribution. — Miocene — Helvetian: Turin, Touraine, etc.; Egypt—Jebel Geneffe, near Suez (*fide* Fuchs); Camp No. 20, between Cairo and Suez; Coll. Geol. Surv. Egypt, Nos. 356, 372; and Jebel Owebid, No. 971.

Description of Figure. — Pl. IX, Fig. 4, horizontal section across some corallites, × 3 diam.

Remarks.—The collection includes a series of massive specimens of a coral, which has the long, narrow, crowded corallites of typical *Solenastræa*. It is only exceptionally that any septa are preserved, a fact which suggests their possible cribriform nature. That the septa are not cribriform may be proved by lateral examination of the septa, which, however, is seldom possible. It is shown by the section on Pl. IX, Fig. 4. The figure does not show the intense secondary mineralogical changes that have occurred in the substance of the corallum.

The coral has all the specific characters of *Solenastræa Turonensis* (Mich.). Locard[2] has described a nearly allied Corsican coral as *Solenastræa Peroni*, which is said to differ from *S. Turonensis* by the smaller size of the corallites (diameter 1·5 mm. instead of 2 mm.) and the less developed columella. The former difference is slight, and the latter may be an accident of preservation, as in *Cyphastræa* septa and columella are so easily removed; while Klunzinger's figures of the Red Sea species shows that the columella varies greatly in different corallites of the same corallum. Thus, his figure[3] of *C. chalcidicum*, Forsk., has no trace of columella in many corallites, whereas it is fairly well developed in a few. The Egyptian specimens agree with the typical forms of *S. Turonensis* in the diameter of the corallites and with *S. Peroni* in the development of the columella.

[1] G. Seguenza, "Cor. foss. terz. Messina," pt. ii: Mem. R. Accad. Sci. Torino, ser. 2, vol. xxi (1864), p. 111, pl. xiii, fig. 3. For better figures see Von Reuss, "Foss. Kor. öster.-ung. Mioc.": Denk. Akad. Wiss. Wien, vol. xxxi (1871), p. 244, pl. xviii, fig. 2.

[2] A. Locard, "Descr. Faune Terr. Tert. Moy. Corse" (1877), p. 219, pl. vii, figs. 5–7.

[3] C. B. Klunzinger, op. cit., pt. ii (1879), pl. v, fig. 8.

Among recent Red Sea species it is most allied to *C. chalcidicum*, Forsk., which Klunzinger's figures[1] do not show to have cribriform septa.

S. Turonensis has been doubtfully recorded in the Egyptian Miocene by Fuchs.[2]

GENUS INDET.

The collection includes two blocks of a Miocene coral (Coll. Geol. Surv. Egypt, No. 998), which are the internal casts of a large flat-topped massive corallum. They are labelled *Isastræa*, but are insufficiently preserved for identification. The corallites are circular, separated by exotheca, the walls appear to have been solid, the septa are long and thin, and there is no columella. This series of characters suggest the genus *Aræcis*. The specimens were collected at lat. 30° 12′ 20″, long. 32° 24′ 30″.

III. EOCENE.

Genus CŒLOSMILIA, Edwards & Haime, 1850.

Cœlosmilia Milneri, nov.

Diagnosis.

Corallum free, tapering below to a sharp point; laterally compressed, so that the transverse section is elliptical. The axis is straight or slightly curved.

Calice shallow.

Septa very jagged; five complete cycles, the members of which are very unequal in size; the primary and secondary septa are thick near the periphery; septa of higher orders thin and short. Septa slightly exsert.

Axial space very large.

Epitheca irregular; when present it consists of a thin layer, horizontally wrinkled.

Dimensions.

	mm.	mm.	mm.	mm.
Height	16 ...	13 ...	17·5 ...	29
Diameter: major ...	18 ...	14·5 ...	14·5 ...	14
Diameter: minor ...	13 ...	10·5 ...	11 ...	11·5

Distribution.—Lower Eocene—Libyan Series: Dungul Wells (lat. 23° 30′, long. 31° 21′), Upper Egypt; Coll. Geol. Surv. Egypt, No. 265.

Description of Figures.—Pl. VIII, Figs. 1, 2, and 3, three specimens seen from the side (Figs. 1*a*, 2*a*, and 3*a*) and in transverse section (Figs. 1*b*, 2*b*, and 3*b*); nat. size.

Affinities.—The simple corallum, the absence of endotheca, of pali, and of columella, the large axial space, the broad interseptal loculi, and jagged septa, are the characters which together

[1] C. B. Klunzinger, op. cit., pt. ii (1879), p. 53, pl. v, fig. 8; pl. x, fig. 11.
[2] Fuchs, op. cit., p. 64.

necessitate the reference of this species to the genus *Cœlosmilia*. The only other genus that needs consideration is *Smilotrochus*, which has simpler and more crowded septa and narrower interseptal loculi.

The nearest allied species is *Cœlosmilia Faujasi* (Ed. & H.),[1] from the Maastrichtian of Ciply, which has a peduncle, although, as the authors of the species remark, the coral probably becomes free when mature. But the Belgian coral is much taller, and narrower; the height is 40 mm. and its diameter 20 mm., whereas the Egyptian species is smaller, lower, and proportionately broader.

Cœlosmilia elliptica, Reuss,[2] from the Oligocene of Castelgomberto, is also an allied form, but has longer, more equal septa, and a small axial space. It is also pedunculate. Another similar species was described as *Smilotrochus cristatus*, Felix,[3] from San Giovanni Harione, but in that species also the septa are less unequal, those of the last orders being much longer than in *Cœlosmilia Milneri*.

The species is named after the distinguished former Financial Adviser to the Khedive, by whose management of the Egyptian finances the Geological Survey of the country has been rendered possible.

Genus STYLOPHORA, Schweigger, 1819.

Stylophora similis (Mayer-Eymar), 1883.

Astrohelia similis, Mayer-Eymar, 1883, "Verst. tert. Birket-el-Qurûn": Beitr. libysch. Wüste, vol. i, pt. 2, p. 73, pl. xxiii, fig. 2.

Distribution.—Upper Eocene: Fayum, in Lake Birket-el-Qurun (Mayer-Eymar), and Coll. Geol. Surv. Egypt, No. 619.

Description of Figure.—Pl. VIII, Fig. 6, two corallites showing the columella, × 3 diam.

Affinities.—The occurrence of a well-developed columella in this coral is alone sufficient to necessitate its removal from *Astrohelia*. The species is a member of Duncan's alliance the Stylophoroida, and of the genus *Stylophora*, of which its nearest ally is perhaps *S. distans* (Leym.).[4] Comparison of the figure here given of two corallites with Leymerie's figures of *S. distans* shows the resemblance between them; the corallum in the latter is granulate, but so it may also have been in the Egyptian species. The specimens are not well preserved, having been polished and worn by sand erosion. Professor Mayer-Eymar's figures do not show the columella, which is not often seen in the five specimens in the Geological Survey Collection. Two

[1] *Parasmilia Faujasi*, Edwards & Haime, "Mon. Astr.": Ann. Sci. nat., Zool., ser. 3, vol. x (1849), p. 245. Edwards & Haime, "Hist. nat. Cor.," vol. ii, p. 177.

[2] A. E. von Reuss, "Pal. Stud. ält. Tert. Alpen": Denk. Akad. Wiss. Wien, vol. xxviii (1868), p. 140, pl. i, fig. 5.

[3] J. Felix, "Krit. Stud. tert. Kor. Vicentin": Zeit. deut. geol. Gesell., vol. xxxvii (1884), p. 382, pl. xvii, figs. 1–3.

[4] A. Leymerie, "Mém. Terr. à Nummul. Corbières": Mém. Soc. géol. France, ser. 2, vol. i (1844), p. 358, pl. xiii, fig. 6.

corallites with the columella are shown on Pl. VIII, Fig. 6. The corallum occurs in cylindrical or flat branches.

Genus LITHARÆA, Edwards & Haime, 1849.

LITHARÆA EPITHECATA, Duncan, 1880.[1]

DISTRIBUTION.—*Cardita Beaumonti* Series: Sind. Lower Eocene —Libyan Series: a little south of Silsila, on the Nile (lat. 20° 40′), Upper Egypt; Coll. Geol. Surv. Egypt, Nos. 165, 176, 183; Dungul Wells (lat. 23° 30′, long. 31° 20′), Upper Egypt; same coll., No. 306.

DESCRIPTION OF FIGURES.—Pl. VIII, Fig. 7, part of the surface of a young corallum with deep calices (No. 183), × 2 diam.; Pl. IX, Fig. 6, part of a hemispherical corallum (No. 306), × 2 diam.

REMARKS.—The coral is represented in the Egyptian collection by two forms—one with a low, flat, broad corallum, like the type of the species; and the other, hemispherical, like Duncan's var. *hemispherica*. I do not see how these Egyptian corals can be specifically separated from the Sind specimens, and so describe them as a geographical variety.

Litharæa epithecata is closely allied to *L. rudis*, Reuss,[2] but the septa are stouter and stronger than in that Oligocene form, which has been recorded by Felix from the Wadi Ramlieh in Egypt.

IV. CRETACEOUS.[3]

Genus PHYLLOCŒNIA, Edwards & Haime, 1848.

PHYLLOCŒNIA TOUCASI, De Fromentel, 1884.

"Pal. Franç. Terr. Cret.," Zooph., p. 549, pl. cliii.

Var. ÆGYPTIACA.

CHARACTERS.—This coral differs from the typical form of the species by the smaller size of the corallites, which are, moreover, somewhat more crowded. In other respects the corallum agrees precisely with the specimen figured by De Fromentel: the costæ are not always alternately unequal, but then they do not appear to be so in the original figure.

DIMENSIONS.

	Type.	Var. *Ægyptiaca*.
Height of corallum	—	42 mm.
Diameter of corallum	—	61 × 87 mm.
Average diameter of corallite ...	8 mm.	4–5 mm.
Average distance of calicinal centres	10 mm.	5–6 mm.
Septa	3 complete cycles.	3 complete cycles.

[1] "Foss. Cor. Sind": Pal. Indica, ser. xiv, pt. 1, p. 23, pl. ii.

[2] Von Reuss, "Pal. Stud. ält. Tert. Alpen": Denk. Akad. Wiss. Wien, vol. xxix (1869), p. 251, pl. xxvii, fig. 2.

[3] A description of the Cretaceous rocks of Abu Roasch, with a diagrammatic map of the fault system in the district, has been given by J. Walther, "L'Apparition de la Craie aux Environs des Pyramides": Bull. Inst. Egypt, ser. 2, No. 8 (1887), pp. 3–13; 2 pls.

Distribution.—Turonian: Bausset, France (De Fromentel); Abu Roasch, Egypt (Brit. Mus. Coll., R. 336, and Coll. Geol. Surv. Egypt, No. 53).

Figures.—Pl. IX, Fig. 1*a*, corallum from above, $\frac{2}{3}$ nat. size; Fig. 1*b*, part of upper surface of corallum, × 2 diam.; Fig. 1*c*, some corallites seen in horizontal section, × 3 diam. Fig. 2, part of horizontal section across another specimen, × 2 diam.

Remarks.—The specimen used as the type of this variety was presented to the British Museum by W. M. Newton, Esq. It is well preserved, and shows the upper surface of the corallum. A weathered specimen sent by the Egyptian Geological Survey proves to be the same species; the external surface has been destroyed, and only transverse sections show sufficient of the septa for determination.

DESCRIPTION OF PLATE VIII.

Figs. 1–3. *Cœlosmilia Milneri*, nov. Libyan Series. Three specimens seen from the side (Figs. 1*a*, 2*a*, and 3*a*) and in transverse section (Figs. 1*b*, 2*b*, and 3*b*); nat. size. Coll. Geol. Surv. Egypt, No. 265.

Fig. 4. *Stylophora asymmetrica*, nov. Helvetian: east side of Wadi Jiaffra, on road from Cairo to Suez; Coll. Geol. Surv. Egypt, No. 644. Fig. 4*a*, part of upper surface of corallum, nat. size; Fig. 4*c*, view of vertical section across the same specimen, nat. size; Fig. 4*b*, one corallite of the same specimen, seen from above, × 2 diam.

Fig. 5. *Plesiastræa microcalyx* (Felix). Helvetian: Coll. Geol. Surv. Egypt, No. 814. Fig. 5*a*, part of upper surface of corallum, × 2 diam.; Fig. 5*b*, part of a horizontal section across the same specimen, × 4 diam.

Fig. 6. *Stylophora similis* (Mayer-Eymar). Upper Eocene: Fayum; Coll. Geol. Surv. Egypt, No. 619. × 3 diam.

Fig. 7. *Litharæa epithecata*, Dunc. Libyan Series: Coll. Geol. Surv. Egypt, No. 183. Part of surface of a young corallum, showing deep calices, × 2 diam.

DESCRIPTION OF PLATE IX.

Figs. 1 and 2. *Phyllocœnia Toucasi*, De From., var. *Ægyptiaca*, nov. var. Turonian: Abu Roasch, near Gizeh. Fig. 1*a*, upper view of the corallum in the British Museum (R. 3,436), $\frac{2}{3}$ nat. size; Fig. 1*b*, part of the upper surface of the same, × 2 diam.; Fig. 1*c*, a horizontal section across the same, × 3 diam. Fig. 2, part of a horizontal section across a specimen in the Coll. Geol. Surv. Egypt, No. 53; × 2 diam.

Fig. 3. *Orbicella Schweinfurthi* (Felix). Helvetian: Coll. Geol. Surv. Egypt, No. 997. Part of a horizontal section, × 3 diam.

Fig. 4. *Solenastræa Turonensis* (Mich.). Helvetian: Coll. Geol. Surv. Egypt, No. 356. Part of horizontal section across several corallites, × 3 diam.

Fig. 5. *Fungia patella* (Ell. & Sol.), var. *lobulata*, Klnz. Pleistocene: Egypt. Coll. Brit. Mus., No. R. 1,308: a view of part of the base, showing the scar of the anthoagathus and the low obtuse spines on the costæ, × 2 diam.

Fig. 6. *Litharæa epithecata*, Dunc. Libyan Series: Coll. Geol. Surv. Egypt, No. 306. Part of the surface of a hemispherical corallum, × 2 diam.

II. — On Meshwork-structures observable in Microscopic Sections of Rocks.

By Grenville A. J. Cole, M.R.I.A., F.G.S.,
Professor of Geology in the Royal College of Science for Ireland.

THIS note deals with a very simple matter, which is perhaps familiar to many workers with the microscope. I believe, however, that it is not referred to in ordinary text-books, and a word or two in reference to it may be useful.

From time to time, meshwork-structures have been described, either in the felted groundmasses of igneous rocks or in the products of the decay of ferromagnesian minerals; and it is frequently remarked that a rectangular arrangement of the constituents of the mesh is clearly brought out when the section is examined between crossed nicols.

One of the most beautiful experiments to illustrate the separation of materials in a crystalline form from a state of fusion is to receive a drop of "candle-grease" from an ordinary commercial candle upon a microscopic slip. Place a circular cover-glass upon it, heat until the material is well fused, and lay it beneath a power magnifying some 100 diameters and between crossed nicols. If the instrument has been previously focussed for a glass slip of the right thickness, no stage of the process of crystallisation will be lost. At first, as cooling proceeds, tiny specks emerge from the dark ground, like stars in an evolving universe. Gradually a delicate meshwork of fine and somewhat wavy rods spreads inwards from the cooling outer circle of the cover-glass. These rods rapidly thicken, while their interstices finally become filled up. But the meshwork effect is still perceptible, and a rectangular arrangement of the crossing fibres is strikingly apparent.

On repetition of the experiment, it may appear surprising that the rectangular mesh extends regularly across the slide, as if some polarity existed between the minute crosses of which it is composed. On still further repetition, it will be plain that the two series of fibres always lie at 45° to the diagonals of the crossed nicols.

On rotating the stage, the meshwork does not rotate; that is, new fibres come into the positions of the former ones, and therefore into the same positions of prominence between crossed nicols.

The secret is, of course, that the crystals of stearic acid are in these positions in a state of maximum illumination, while those lying in other positions have a much feebler effect upon the eye, or may even be totally extinguished. Even if the crystals of such an aggregate have oblique extinction, in every radiating or hap-hazard group there are likely to be four crystals which are at 45° to their positions of extinction; these will impress themselves upon the eye, and a cross will be the result, though its components will not have their longer axes at 45° to the diagonals of the nicols. The effect is far more noticeable where, owing to the thickness of the section, or to the strength of the double refraction of the material, the interference-colours are of a high order. I have seen no more striking example than in a schist with irregularly scattered plates

of muscovite, which I recently received for examination from the Geological Survey of the United Kingdom. The cross-sections of the mica, coloured in pinks and greens between crossed nicols, stand out in two distinct series perpendicular to one another, so as to suggest a remarkable double foliation. On rotation of the stage, however, all chance of misconception was removed.

It would be unwise to suggest that this or that rectangular mesh, described by various authors, may be a structure visible only between crossed nicols, and with no existence in reality. But it is easy to extend the observation to the mesh-structure of decomposing olivine, and to dispose of some of the difficulties as to the presence or absence of rectangularly arranged fibres in particular examples. I am indebted to Miss C. A. Raisin, B.Sc., for the loan of several sections of serpentine from the Rauenthal, for comparison with other serpentines in my own collection; and the former have proved of special service. While fully agreeing with Miss Raisin [1] and Professor Bonney [2] as to the former existence of olivine in the Rauenthal rock, I would not lay great stress upon the rectangular appearances seen in the meshwork of this or other serpentines.[3] Where the mesh-structure is on a coarser scale, or on using a higher power, rectangular mesh-structures are rarely seen, since the eye does not readily take in the requisite number of illuminated bars at the same time; where, however, the structure is finer—i.e., where the original cracks of the olivine were closer together—a rectangular effect is readily produced, by the prominence of the doubly refracting decomposition-products lying along those cracks or portions of cracks that happen to be perpendicular to one another.

I cannot help thinking that von Drasche's [4] "deutliches quadratisches Netzwerk" in some parts of the "serpentine-like rock" of Windisch-Matrey may have been quite local, or even due to accidents of observation, especially as the author states that the fibres in most parts of the rock intersect at very various angles. The rectangular effect is well shown in his plate, fig. 2; and prominence was given to a similar arrangement by Hussak [5] during his investigation of the antigorite-serpentine of Sprechenstein, near Sterzing in Tyrol. This rock was photographed by Cohen [6] in the same year, from one of Hussak's specimens, between crossed nicols, and the figure is still better known from its occurrence in Rosenbusch's "Massige Gesteine." In his description of the plate, Rosenbusch uses for the arrangement the term "Balkenstructur," which is adopted also by Zirkel.[7] Cathrein [8] also comments on

[1] "The Nature and Origin of the Rauenthal Serpentine": Quart. Journ. Geol. Soc., vol. liii (1897), p. 255.

[2] "Note on Specimens of the Rauenthal Serpentine": Geol. Mag., 1887, p. 68.

[3] See Miss Raisin, op. cit., p. 263.

[4] "Ueber Serpentine und serpentinähnliche Gesteine," Tscherm. Mitth., 1871, p. 5 (Jahrb. d. kk. geol. Reichsanstalt, Bd. xxi).

[5] "Ueber einige alpine Serpentine," Tscherm. Mitth., 1883, p. 70.

[6] "Sammlung von Mikrophotographien," pl. lxv.

[7] "Lehrbuch d. Petrographie," 2te. Auflage, Bd. iii (1894), p. 384.

[8] "Beiträge zur Petrogr. Tirols": Neues Jahrb. für Min., 1887, Bd. i, p. 152.

a "Balkennetz," and agrees with Hussak on its significance in indicating the pyroxenic origin of certain serpentines. F. Becke,[1] as is now well known, has diminished the importance of Hussak's suggestion by indicating similar structures in an antigorite-serpentine derived from a true olivine-rock; and he regards the antigorite plates as developed along the cleavages of the original olivine grains. This is the view taken by Miss Raisin in dealing with the rectangular structures of serpentine; while Professor Bonney, with much probability, regards the irregularity of the mesh-structure ordinarily seen as due to the imperfect character of the cleavages in olivine. In 1891 I wrote[2]: "These needles, picked out by the use of the polariscope, are so frequently at or nearly at right angles to one another as to suggest their development along the cleavage-planes of the mineral that has been pseudomorphosed. It is often stated that the serpentine in such cases has been derived from pyroxene; but the structure is extremely common in company with others referred as certainly to olivine." Becke's paper on the Stubachthal has fully confirmed the latter statement; but my present note is intended to suggest that a true rectangular meshwork, continuous throughout the whole of an olivine grain, is not so frequent an occurrence as might at first appear. In the first place, the more brightly illuminated part of the cross-section of a curving "antigorite" or other plate may catch the eye and give a fictitious appearance of regularity. In the second place, a second rectangular meshwork may sometimes appear during rotation within the grain that is being observed, the former one being now extinguished; and we thus see that several systems of cracks, with corresponding alteration-films, occur, and that these cracks are picked out in pairs by the use of polarised light. No one can deny that olivine is often broken up into approximately rectangular blocks, even in the fresh state; for the larger crystals observable in many basalts show this character when examined with the lens. Consequently, a rudely rectangular structure is common in the products of alteration. But I believe that its regularity is easily liable to be exaggerated; and the same consideration becomes far more important when extended to sections of metamorphic rocks, containing tufted chlorites, micas, and so forth, lying in all directions through the mass.

In conclusion, the reality of the optical effect above described cannot be more happily demonstrated than in the *photographs* accompanying Mr. Arnold-Bemrose's paper[3] "On a Quartz-Rock in the Carboniferous Limestone of Derbyshire." The irregularly-lying quartz needles have been photographed in section between crossed nicols; and a rectangular effect, which is just apparent in fig. 2, becomes markedly so in the more fine-grained material shown in fig. 3.

[1] "Olivinfels und Antigorit-Serpentin aus dem Stubachthal," Tscherm. Mitth., Bd. xiv (1895), p. 275.

[2] "Aids in Practical Geology," p. 164. The objects here called "needles" are the cross-sections of the little plates developed along the cracks.

[3] Quart. Journ. Geol. Soc., vol. liv (1898), pl. xii.

III.—A Numerical Scale of Texture for Rocks.

By H. Stanley Jevons, B.A.

WHEN reading through descriptions of hand-specimens of igneous rocks I have often found a difficulty in forming an exact mental picture of the appearance of the rocks because of the very meagre information usually given as to the coarseness or fineness of their texture. The following simple method would, I believe, to a great extent obviate the difficulty now experienced in giving such information.

Since the degree of texture of a rock depends on the average volume of its constituent crystals, the theoretically correct method of expressing it is by stating the latter in some standard measure. The determination of this average volume is, however, practically impossible, so we fall back on the next best method for its expression, that of measuring the average area of the individual crystals exposed on any surface of the rock. One way of doing this is by counting the number of crystals in a given area, but it is a very cumbrous process even with the best appliances I could devise. The method to be described consists in directly measuring the length of a number of crystals and calculating their average length. Its fundamental idea is the average area of the crystals, but this is expressed by means of their average linear dimensions, so that the figures, though originally lengths of crystals, are primarily symbols for their areas, a fact which it is important to bear in mind when a crystal of irregular outline is being measured. They are thus not proportional to the areas they represent, but to their square roots. As it is desirable to have a conventional usage on such points, I have chosen the length as the dimension for measurement, though theoretically any other would have done, and the millimetre as the unit in which it is expressed, because of its convenient size. As the same unit will probably be used by all, it will be unnecessary to mention it each time, 3, for instance, being understood to mean 3 mm.

The only apparatus required is a small scale, preferably of ivory, about eight centimetres long, divided into millimetres throughout and into half-millimetres for two centimetres from both ends.[1] To measure the degree of texture with this, one first studies the surface of the hand-specimen, fixing with the eye on several crystals which appear to be of about the average size, and then one measures these to the number of about a dozen, taking the average. If the crystals are oblong the diagonal should be measured, if oval the greatest diameter (when lath-shaped the fact must be mentioned); but if they are very ragged one must simply measure the conspicuous parts, for it is the size of these, after all, which gives the rock its appearance of a coarse or fine texture. Some examples later on will perhaps render these directions clearer. The size of the individual crystals is fairly constant in some rocks, but in most the majority of the crystals will be of about the same size, while the rest will vary

[1] Such a scale may be had of Messrs. Stanley & Son, Great Turnstile, London.

between certain higher and lower limits. In this latter case a statement of the general average size will still give a very good idea of the appearance of the rock, but for the sake of accuracy it would be well also to state the limits. As examples I may quote the following readings I have taken from various hand-specimens: Carrock Fell gabbro, 8; minette from Sale Fell, 1·5; Shap granite, 3 to 4, with porphyritic crystals, 25; Buttermere granophyre, 2; the tonalite of Monte Tonale, 4; a granite from Ben Nevis, 2·5, with interstitial matter about 0·3, and porphyritic crystals up to 7.

The principle and method are equally applicable to microcrystalline rocks if one uses a micrometer scale in the microscope and reads the lengths of the average crystals in fractions of a millimetre. For instance, a specimen of the nosean-phonolite of the Wolf Rock, Plymouth, is in texture 0·084; with porphyritic crystals, 1·0. Perhaps it may be interesting by way of illustration to give the measurements by which the size of the porphyritic crystals was determined in this case. They are 23, 32, 60, 26, 40, 80, 40, 40, 28, 90, 40 and 60, mean 47. Since twelve divisions of the scale equal ·254 mm., the average length of the crystals measured is ·996, say 1 mm. That there is a considerable difference between the maximum and minimum lengths must be admitted (a rather greater one here than usual, I think), but still there is a general average size, which the eye can get hold of and distinguish easily from one a little higher or a little lower. As another example I may mention a biotite-olivine-dolerite from Kintellan, Argyleshire, which is in the groundmass ·89; porphyritic constituents 2·03.

The following measurements which I have made of some of the figures in Teall's "British Petrography" may be of service as a kind of criterion by which any person may see whether he is measuring in the way I have explained. The results quoted are the direct measurements, as I have not troubled to reduce for the magnification. Plate xxv, fig. 2, and pl. xxvii, fig. 1, are both easy to measure, and give 15 and 16 respectively. Pl. viii, fig. 1 is not so easy, because many of the crystals are very ragged, but if each large patch of viridite be taken as representing one crystal we get the figure 14, or taking the magnetite separately (at 8), we have for the remainder 16. As an instance of how to measure a ragged crystal I will take the brown hornblende in the lower half of the figure. From the bottom right-hand corner to the rounded top I make it 21, and I neglect the ragged tail which projects upwards on the right. This procedure may seem arbitrary, but it is really necessary, because otherwise such crystals would receive a value out of all proportion with their area, the quantity I have already shown that we are really endeavouring to express. In the case of ragged crystals, therefore, discretion must be used to give a number which would probably represent the linear dimensions of a crystal of the same area but of regular outline.

In pl. xii, fig. 2, the constituents must be mentioned separately, thus—porphyritic crystals (only one in the figure), 23; lath-shaped felspars, 8; augites, 3·5; iron-ores, 1. One of the most difficult is

pl. xix, fig. 1, whose structure is that shown macroscopically by many gabbros. It is impossible in this case to separate out a number of individual crystals and measure them, so one must scan the picture until one has an idea of the average apparent size of the crystals, fix upon two or three well-defined ones which seem to express this, and measure them. The crystals I fixed upon when measuring this figure were a plagioclase just above the centre, marked "10" in the key, and a pyroxene to the low left, marked "7." These measure 19 and 14 respectively in greatest diameter, so that one might quote 16 or 17 as a rough average value. It must always be understood that with a rock of this structure the number given does not represent an actual measurement of crystals, but is only a measure of the general impression the eye forms of its texture, so that it cannot be very definite.

The ophitic structure usually involves the quotation of at least three numbers, for the ophitic plates, the included granules, and the interstitial matter respectively.

With regard to the time taken by these measurements, I may say that a hand-specimen takes me about three minutes and a slide about five. The most encouraging feature in the method is that the eye can at a glance distinguish between rocks, say, of texture 1·5 and 2, though by the method now in use one could only describe them both as medium-grained. I think it very likely that a little practice will enable one to give roughly the degree of texture of a rock without any measurement at all, as, for instance, to say, "Texture granitic, from 2 to 2·5," almost at a glance, though it would of course usually be desirable to check the statement by measurement. It is almost needless to add that the method is applicable to sedimentary rocks equally with those of igneous origin.

In conclusion, I may say that several of my friends, among them Professor Bonney and Miss Raisin, have kindly measured some specimens which I placed before them. The coarse-grained rocks presented some difficulties, which led to their not giving quite concordant figures on the first attempt, but the results were on the whole distinctly encouraging, especially among the finer-grained rocks. I venture, therefore, to bring this idea before the notice of petrologists, because, although it does not entirely do away with the personal element in the description of the texture of rocks, it has at least the merit of greatly reducing it, and of so rendering comparable the descriptions of different authors.

IV.—The Surface Geology of the North of Europe, as illustrated by the Åsar or Ösar of Scandinavia and Finland.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

(*Concluded from the May Number, page* 206.)

LET us next turn to the postulated subglacial rivers. How can we conceive of tunnels of ice 100 miles long running in one direction, 300 feet high, and only 20 or 30 paces wide? The difficulty about the provenance of the stones, again, is equally great

or even greater, and more insurmountable in such a case than it would be in the case already cited.

Those parts of Sweden whence the stones in question were derived are so comparatively low that we cannot conceive an ice-sheet existing on the scale postulated by the glacialists which did not at the same time bury all such rocky surfaces fathoms deep under ice. We have already, in many ways, criticized the transcendental notion involved in so-called "ground moraines," and the mechanical process which the wilder American geologists euphoniously describe as "*plucking*." "Plucking" is the process by which ice, under a pressure of many tons to the square inch and moving so slowly that the movement would be virtually inappreciable in the nether layers of the ice-sheet, is supposed to have had the capacity of breaking up its own bed and performing feats of quite superlative dentistry. This view, which I believe to be utterly fantastic, and which has never been supported by any mechanical argument or by anything better than an *obiter dictum*, is the only refuge for the believers in ground moraines as the explanation of the Swedish åsar. But this plucking proceeding is not all that is required. Granting that we may indulge ourselves in a *plucking* theory, in order to pluck up stones the ice must be in contact with its stony bed, and we altogether fail even to understand the process when the ice is separated from its bed by a padding of sand or gravel or boulders. Can it continue to "pluck" through this intervening cushion, and if so, how is it to continue doing so when the subglacial deposit becomes 40 or 50 or a 100 yards thick? If we discard the plucking process as ridiculous, whither is the glacialist to turn?

When a stream began to flow underneath an ice-sheet, how could it possibly obtain materials from any other source to pile up a mound a hundred miles long, of uniform height, and rising a hundred yards above the level of the bed of the ice-sheet itself? It could not derive them from the rocks underlying its own bed, for these would be protected from denudation by the sand and gravel and stones already there. Suppose it were possible to get the stones (stones formed of the hardest crystalline rock), how could it roll them into absolutely rounded and curved forms? On such a bed basalt and gneiss are not easily worn into these shapes by being rolled over beds of sand and clay containing a sprinkling of stones. If it were strong enough to roll them and toss them about, the subglacial stream must have been a torrential river, and if so, as we have said, it must have scoured out the sand and brickearth completely, instead of leaving them mixed heterogeneously with the great boulders.

I have referred to the difficulty of assigning continuous mounds of the same general height and breadth, and extending over great distances, to the handiwork of rivers, whose beds naturally and necessarily grow wider as they march from their source to their outfall; but in the case of the Scandinavian åsar the subglacial theory presents an additional difficulty. According to the glacialists, the Scandinavian ice-sheet extended to the Carpathians and to

Central Russia. How is it, then, that the åsar did not continue their strange march right away to these goals? Did the subglacial rivers stop short where the various Swedish åsar terminated their journey? If so, what became of their water? Was it frozen again? How was this? The further south we travel, the warmer must the climate have been under the same conditions, and consequently the more water must have flowed from the ice-sheet. Its drains, the subglacial rivers, must therefore have increased in volume instead of dying out, and surely when they reached the flat country of Poland and Russia must have become more and more liable to deposit materials in their beds. How is it, then, that the åsar do not continue their march to Cracow? But apart from all this, let me repeat a question I have already asked, and which presents itself to a traveller who has crossed the country in a very grotesque fashion. I wonder if the champions of subglacial rivers as the depositors of the åsar have ever drawn a series of contour-lines, say from Dalecarlia to Silesia, and if so, how do they propose to explain the flow of any river, whether under an ice arch or not, along such a course, not only across the undulating surface of Sweden, but across the Baltic depression?

There remains another element which we have not yet considered, namely, the large, sometimes portentously large, angular and subangular blocks which occur in the surface layers of the åsar, and sometimes in large numbers on their backs, the ås near Gamla Upsala being a good example. Among the many boulders we noticed, there was one whose cubical contents must have been 36 yards. Similar subangular and angular blocks have occurred in the deposit containing marine shells at Upsala. How are we to explain these blocks and their occurrence where they are found, by any kind of fluvial action? Rivers must become desperate torrents, such as occur sometimes in the ravines of the Caucasus and the Western Himalayahs, to move such stones at all, and how could they be deposited by rivers in the midst of stratified sands with marine shells, and on the tops of the åsar? How comes it they are not found at the bottom, where the cannon-shot gravel so often occurs? When it is said they were transported by ice-rafts, how could they get on to the backs of the ice-rafts? If frozen to their under surface, the difficulty is still greater, for torrential rivers do not freeze into solid masses, nor does their ice-covering become attached to boulders which may be lying on their beds. So far as I know, rivers in Scandinavia do not now carry about and deposit such stones, except when there may be an occasional collapse in their banks; and if the glacial rivers derived them from disintegrated banks, it only removes the difficulty of their explanation one step further back. But those who appeal to ice in this fashion forget the relative age generally assigned to the surface beds of the åsar. The great majority of geologists are emphatic about the surface beds of the åsar containing marine shells being Post-Glacial. If so, then we have a double crux, for not only have we to explain the existence of gigantic erratics far away from their parent beds,

but to explain them and their portage when anything but a glacial climate is testified to by the mollusca occurring with them. It seems, therefore, impossible to appeal to ordinary rivers in order to explain these angular blocks; much more so is it difficult to account for their portage by subglacial or supraglacial rivers. In neither case do such rivers carry ice-rafts. Nor can we see how ice-rafts could arise in either of them. Ice-rafts are the broken pieces of ice which once covered subaerial rivers. The only ice which covers subglacial rivers is the tunnel of ice through which they flow, while supraglacial rivers do not freeze on their surface, but cease to exist entirely in winter, for they are the result of the melting of the surface of the glaciers and nothing more.

In every way we view the fluviatile theory of the origin of the åsar it seems to collapse when analyzed, and if I could be astonished at anything which the glacial geologists choose to formulate I should be greatly surprised at its continued existence in their textbooks. The time is assuredly coming when the reputations which have been built up on such science will as assuredly collapse. No wonder a desperate struggle is made to maintain them in some quarters, and a portentous silence prevails in others. Putting aside the fluviatile theory, whither are we to turn for an explanation of the åsar but to the primitive theory of all; the one which commended itself to the earliest Swedish geologists, namely, that they are in some way or other the result of the action of the sea during a period of submergence. Thus Swedenborg urges that the existence of a former widespread ocean is proved by the mixture of substances in the åsar of sand and gravel, of clay, and large masses of rock and boulders. He urges further that the polished and triturated appearance of the stones in them was the work of the sea, and the slope of the ridges he thinks proves that they were thrown up by the sea into great accumulations, and so formed into lengthened ridges. He argues that the fact of the ridges running north and south shows that the same winds prevailed in Diluvian times as do now, and he appeals to the principle of hydraulics to show that the sea could have done this kind of work. Robert, writing as far back as 1836, says: "Les collines de sable du N., ou ôsars comme on les appelle vulgairement, ont été formées au sein des eaux de la mer par l'effet des courants, phénomène encore en action." The sea in its normal attitude was appealed to to explain the åsar by two other acute, later writers, namely, Ch. Martins and Robert Chambers. The former, an extreme champion of the Glacial theory, says: "The åsar form one of the numerous proofs of the immersion and emergence of the Scandinavian surface. . . . . The åsar were the work of the sea during the time of the Scandinavian immersion. They are veritable dunes (the *Revler* of the Jutland coast), with a cross-bedding in their stratification, formed by the waves which traversed these ramparts and there deposited the pebbles and sand which it had removed from the bottom of the sea. The pebbles in the åsar are never striated. If they ever had any striæ these have been

removed by their being rubbed down by the sea," etc. (Bull. Geol. Soc. France, 1846, p. 97.) R. Chambers, writing in 1850, after speaking of the angular drift of Sweden as the result of glacial action, continues: "This rubbish has afterwards been under the sea, which, detaching certain portions, has worked the stones into round forms, separated the sand and clay, and left the whole in a new arrangement, namely, that of terraces with long branching ridges or banks." These ridges he connects with the Irish eskers and the Scotch kames, but says they are specially characteristic of Sweden, where they extend for hundreds of miles without any regard to the interruption of lakes or rivers, sometimes thirty, sometimes fifty, and occasionally not much less than a hundred feet in height above the base; and he attributes them to the agitations of a sea which had succeeded to the reign of the glacial influence. ("Tracings in the North of Europe," p. 238, etc.) Erdmann, writing in 1868, accepts the conclusions of Martins and Chambers, and speaks of the åsar as "d'anciennes jetées litorales accumulées et remaniées par la mer" ("Exposé," etc., p. 42). This view is a good deal more rational than that which attributes the åsar to the operation of rivers, subglacial or otherwise.

We can hardly account for the formation of the boulders which make up so large a portion of the åsar except by the intervention of the sea. These boulders are, so far as my experience goes, quite different to river shingle. Their enormous and portentous number, their widespread distribution, the very hard crystalline rocks out of which they have been rolled and fashioned, all testify in a most effective manner to the operations of a turbulent sea on a shallow bottom acting upon the débris of crystalline rocks, and acting for a long time. They bespeak, in fact, a period of long depression. They seem to me to be the complementary phenomenon to the polished and rounded surfaces of Scandinavia, to have been fashioned at the same time, and to have been, in fact, the main instruments in the hands of the sea in rounding and polishing these surfaces, being themselves rounded in the process. They present as few traces of ice-action as cannonballs or Beecham's pills do.

Secondly, the sands which form the so-called sand åsar, and form also conspicuous beds in other åsar which are nearly always, if not always, stratified and false-bedded, seem to me to be marine sands, and nothing else. I cannot in any way distinguish them from well-known barren marine sands elsewhere, and notably those of Dalecarlia, which occur there sometimes as åsar and sometimes as thick and well-stratified beds covering a wide extent of country. These widespread stratified sands of Dalecarlia and their lessons were especially noted by Murchison. "In approaching Hedmora," he says, "or ascending to that town, which lies about 150 or 200 feet above the River Dal Elf, the whole tract is one of undulating hilly sands . . . . resembling the bottom of a former sea. . . . . In approaching Sater these sands, constituting linear åsar here and there united by cross bands or bars, are covered by worn boulders and gravel, and further on the åsar are entirely composed of water-worn

boulders. . . . . The river banks at Sater, as at numberless places on the Dal Elf, consist of mounds of finely laminated sandy loam." (Q.J.G.S., iii, 372.) Murchison goes on to describe the sometimes finely laminated sands which are seen in following the Dal Elf through the fertile tracts of Gustafsland (id., p. 373). I have recently been spending some days in this same district, and have been deeply impressed by the same facts, and notably as they occur about Leksand and thence to Insjon.

A third notable testimony to the marine origin of the åsar is the presence in several cases in their upper layers of marine molluscs like those now living in the Baltic. At Upsala I collected numerous specimens of *Tellina Balthica, Cardium edule, Littorina litorea,* and *Mytilus edulis.* The last-named were much decayed and reduced to fragments. They still retained their colour, which gave a purple tinge to the clayey bed in which they lie.

This kind of evidence is a very potent support to the view that the åsar are, in fact, of submarine origin, and witness, as so many other facts in Scandinavia do, a recent submergence of a large part of the country. It is, nevertheless, clear that when we examine other features of the åsar we cannot attribute them to the ordinary operations of the ocean, and I confess I cannot see in them, as some others have done, a kind of sea-beaches or dunes. Their shape, their internal structure, the alignment of the stones in them; the fact that they consist of a number of parallel ramparts; the further fact that their main trunks have a number of branches; their occurrence at all levels from 2,000 feet downwards; their running up and down hill and being distributed entirely independently of the contours of the country; their sometimes occurring athwart each other and sometimes as cross pieces joining two separate åsars; the rounded and elliptical forms they assume when their continuity is broken: all these facts seem to be at issue with their having been beaches.

On the other hand, the sea in its normal moods does not diversify its actual bed with such ramparts as these. The sea in its normal action is a great leveller and smoother of its beds into soft and curving outlines, and does not lay down upon it a succession of ramparts with steep sides and running for scores of miles in direct lines. Nevertheless, it is from the operations of the sea, not in its normal but in its abnormal moods, that the only explanation of the åsar which fits in with the facts is derivable, and has long ago been derived. Playfair has a pregnant passage on this subject written long ago. "Sandbanks," he says, "such as abound in the German Ocean, to whatever they owe their origin, are certainly modified, and their form determined, by the tides and currents. Without the operation of these last, banks of loose sand and mud could hardly preserve their form and remain intersected by many narrow channels. The formation of the banks on the coast of Holland, and even of the Dogger Bank itself, has been ascribed to the meeting of tides, by which a state of tranquillity is produced in the waters, and in consequence a more copious deposition of their mud. Even the great Bank of Newfoundland seems to be

determined in its extent by the action of the Gulf Stream. In the north-east the current which sets out of the Baltic has evidently determined the shape of the sandbanks opposite to the coast of Norway, and produced a circular sweep in them, of which it is impossible to mistake the cause." (Playfair's "Illustrations," pp. 417–8.) So much for an old master, who was also a champion of Huttonian methods in geology. In more recent times the same lesson has been well and continually pressed by Mr. Kinahan in regard to the Irish eskers, which are really small forms of åsar. I will quote a passage or two, which I cannot improve upon. He says: "The eskers are modifications of the banks and shoals which accumulated at the colliding and dividing of the 'flow' tide currents of the esker sea, similar to those that are found in the seas round Great Britain and Ireland at the present day. In the Irish Sea, in the vicinity of the Isle of Man, there is a meeting of the north and south 'flow' tide waves or a 'head of the tide.' Here the tidal currents meet and neutralize one another in one place, forming a mass of currentless water that simply 'rises' and 'falls' and deposits there silt and other materials. The other heads of the tide in these seas are south and east of England—in the Straits of Dover and between Norfolk and Holland. But in these places there are different results, as the currents collide and pass one another for greater or less distances, and at their edges, or the junction of the different currents, long banks of gravel and shingle accumulate. It is also found that long banks of gravel and shingle may form at the dividing or splitting up of the 'flow' tide current. This is exemplified off the south-east coast of Ireland. From Greenore Point a main current runs northward up the Irish Sea, while secondary currents branch off into Wexford Bay; and at the junction of these currents with the main current there are long banks between Greenore and Wicklow Heads." Again, he says: At the half tide or "awash" portions of banks, and in other shallow places where two currents collide, there are esker-like ridges; as St. Patrick's Bridge between Kilmore and the Saltees, county of Wexford, and on the Dogger Bank, off the mouth of Wexford Harbour. *No action but marine at the present day forms ridges at all like the eskers.* ("Geology of Ireland," pp. 225–230.)

The åsar are, in fact, very large and glorified eskers. The shape of the åsar, and their occurring in a parallel series of mounds, point to a further fact, namely, that the moving mass of water must have been separated into a number of more or less parallel currents, at whose colliding edges the long banks were accumulated. This feature is also at once explained when we examine the contour of the country, and it has been pointed out by Murchison with his usual insight, and been apparently overlooked by his successors. He points out how the åsar in the neighbourhood of Upsala have long ridges of granitic rock running parallel to them, and he says they appear to have here assumed their linear direction in consequence of the rocky elevations on their flanks. The prevalent linear or

north-and-south direction of these masses has necessarily been determined by the chief physical features of Sweden, which consist of frequent alternations of ridges of crystalline rocks and longitudinal depressions.

Murchison further points out how, when we get away from these controlling ridges of rock, the åsar depart from their typical form. Thus, he says, in the tract between Danemora and the little seaport of Kakholm, the åsar, consisting of true rolled and sandy detritus, are frequently arranged in circular heaps of about 100 paces in diameter, each capped by coarse angular blocks. "Now, the water-worn materials are, it will be observed, thus circularly grouped on the lowest elevations in the midst of small plains or flats, from one to two and three miles wide, *which are devoid of those distinct longitudinal encasing ridges of granitic rocks whereby the osar have usually obtained their prevailing long and ridge-like character.*"

In other cases, again, the åsar simulate the ordinary "crag and tail" formation, which, as Sefstrom urged, was the case in Sweden with most of the smaller ones. A well-known instance is that at Kinnekulle, on Lake Wenern, which I have lately examined, and where a train of sand and boulders, after the fashion of an ås, is most clearly, as Brongniart urged, the result of some watery current speeding over the land and leaving a train of débris behind it on meeting with an obstacle.

All the facts, therefore, seem to concur in claiming as the efficient cause of the Swedish åsar great masses of water, sometimes rushing in a series of more or less parallel currents, colliding and elbowing each other and dropping their burden along their edges, and sometimes coalescing into a more or less continuous flood. The abnormal size, the great length and height, and the portentous masses of materials comprised in these mounds, and especially the great size of their contained boulders, necessitate our postulating that the rush of waters must have been on a corresponding scale.

There still remains the question as to whether the åsar were the result of the diurnal (tidal) operations of a turbulent ocean or the rapid and sudden action of a great and cataclysmic rush of water, such as we have on other grounds postulated. In regard to this question, they present some features which seem to me to be conclusive.

In the first place, if they had been the result of the diurnal action of the sea, their internal structure would have been uniform. Instead of this we find that, while the great mass of the materials in most of them is arranged in heterogeneous fashion, being formed of a medley of different-sized boulders, their upper layers consist of stratified sands, finely levigated and laminated clays and brick-earths, mixed with light shells, or they are formed entirely of sands marked by violent cross-bedding, pointing very clearly to a great flood which threw down the great mass of its burden regardless of its gravity, and ended up, as floods always do, by depositing over the previous load the finer contents which it held in suspension in laminæ and layers. The very fact of the great mass of the substance of the coarse åsar being heterogeneous and

unarranged shows that if thrown down by water it could not have been by a succession of efforts, which would have laid down stratified beds, but by one impulse of a most powerful and portentous character.

This is again testified to by another fact, which I have not seen noticed, but to which I can vouch for from personal observation. When a section occurs in an ås and the section has been slightly weathered by the wind, it will be seen that in many cases, where the materials are fine, and consist of sand or clay or fine pebbles, and lines of stratification and laminæ occur in them, that these lines resemble those to which I have called attention occurring in the cliffs at Cromer. They form perfectly continuous lines of curvature extending from the top to the bottom of the deposit, showing that the whole deposit has been the result of one impulse, and not of many. This was especially beautifully visible in an open section I noticed close to Omberg, in West Gothland, which I recently visited. This lamination is a great deal commoner in the ås than is generally supposed. It often requires the face of the section to be slightly wind-weathered before it is disclosed, and I am convinced that it will be found pretty nearly everywhere when no large boulders occur. Wherever the rush of water was sufficiently great to carry with it the large stones, then, it would seem, it laid down its load heterogeneously. Where the rush was less marked, and the water could only carry lighter materials, these lines of stratification were developed.

The most striking and conclusive proof, however, that these gigantic ramparts were thrown down by some rapid and portentous movement of water rather than by exceptional tidal action, is the fact so much overlooked by those who have written on the åsar, namely, their running up and down hill without consideration for the lines of drainage, and this, too, in their line of march. No tide, no race, no movement of water of a torrential character, such as we know it, in any of the oceans or seas of the world, would drive along such a great mass of water in a number of parallel currents, keeping the same lines of movement athwart hill and dale, and lay down enormous masses of heavy unsorted stones in gigantic ridges.

To do this the water must have been not only enormous in quantity, but the impulse which drove it must also have been of quite a cataclysmic character. We can compare it only with the great waves of translation which followed the earthquake of Lisbon, or those which followed great earthquakes in Java some years ago, and of which another example occurred in Japan quite recently. These are the models and types to which we must turn in explaining the åsar and other phenomena of the Drift. We have only to multiply the potency of the cause and the problem is explained, and this, as we have seen, the critical examination of the facts enables us to do. The sudden upheaval and breakage of the solid strata in Central Sweden over several degrees of latitude underneath a widespread sea—this is what the facts compel us to accept, and this is sufficient to solve our difficulty.

To conclude, therefore. The present evidence of the âsar seems to me to completely support the view urged in previous papers from other facts and premises, namely, that Scandinavia was recently very largely submerged by the sea, which covered it for a long time, which smoothed and rounded its surface, and which rounded and smoothed its myriads of boulders; and that this sea was eventually drained and discharged by some rapid and sudden upheaval of its bed, causing a perhaps unprecedented diluvial movement. It was this rapid movement of a vast rushing sea, driven from its bed by the upheaval of that bed, which, as we saw in a former paper, accounted for many of the facts in the recent geology of Scandinavia. It alone, it seems to me, accounts for the various features presented by the Scandinavian âsar, and which bear no trace of any kind which can justify us in calling in ice in any shape to explain them.

V.—Woodwardian Museum Notes.

A Carboniferous Brachiopod (*Eumetria? serpentina*, De Kon.) new to Britain.

By F. R. Cowper Reed, M.A., F.G.S.

In rearranging the Carboniferous fossils in the Woodwardian Museum, I met with a specimen labelled *Athyris*, n.sp., which reminded me of the form described by De Koninck[1] as *Terebratula serpentina*. On careful examination I am convinced that it belongs to this species, and the following is a description of our specimen:—Shell subovate, terebratuliform, widest at about one-third its length from its anterior edge. Valves moderately convex, slightly flattened anteriorly, and devoid of sinus and fold; margin entire and regular. Ventral valve a little less deep than dorsal valve, and furnished with a slightly recurved beak truncated by a large circular foramen, bordered in front by a pair of deltidial plates. Surface of both valves ornamented with straight, radiating, very faint ribs, 60 to 70 in number, arranged in a regular close series separated by weak narrow furrows. Some of the ribs bifurcate at about half their length, and those near the hinge-line curve gently backwards. Shell substance finely punctate. Concentric striæ of growth are distinct on both valves. Length, 25 mm.; breadth, 22 mm.; dorsi-ventral diameter, 12 mm.

Our specimen was found by Mr. E. B. Tawney in the Lower Limestone Shale of Clifton, Gloucestershire, and the Tournai beds in which the Belgian specimens occur appear to be on the same stratigraphical horizon. The faunas of the Lower Limestone Shale of Britain and of the calcareous slates of Tournai are in many respects closely similar. De Koninck[2] in 1887 placed this species in the genus *Acambona* of White,[3] but the latter, in his original definition of this genus, gave the absence of a foramen in the ventral valve as a distinctive feature. Since

[1] "Descr. des anim. foss. qui se trouvent dans le terr. carb. de la Belgique" (1843), p. 291, pl. xix, fig. 8.

[2] "Faune du Calc. carb. de la Belgique" (1887), vol. iv, pp. 96, 97, pl. xxii, figs. 25–31.

[3] Proc. Boston Soc. Nat. Hist., vol. ix (1862), p. 27, figs. 1, 2.

De Koninck figures and describes a foramen in the Belgian examples (with which ours agrees), Hall [1] is inclined to consider this species as congeneric with *Eumetria vera* (Hall) from the Kaskasia Limestone of the Lower Carboniferous Series of America. But until we know the internal structure of the species, we cannot positively decide to what genus it should be assigned. Waagen [2] has suggested that it may belong to his genus *Uncinella*, from the Productus Beds of the Salt Range of India. In the description of *Retzia ? carbonaria* (Dav.) from the Lower Carboniferous Shales of Skrinkle, Pembrokeshire, Davidson [3] mentions *Terebratula serpentina*, but *Retzia ? carbonaria* is held by Hall [4] to belong to the distinct genus *Hustedia*.

VI.—Note on a large Boulder at Wimpole Hall, Cambs.

By F. R. Cowper Reed, M.A., F.G.S.

ABOUT five-and-twenty years ago a large boulder, lying in the garden of Wimpole Hall, near Royston, was pointed out to the Rev. Osmond Fisher by the Lady Hardwicke of that period, and she informed him that it had been brought from near Old North Road Station when the hill there was lowered. As its dimensions and nature had not been determined, Mr. Fisher invited me to accompany him to Wimpole on April 22nd in order to examine it, having previously obtained permission from the present owner of the property, Lord Robartes. After a brief search the boulder was discovered lying about 30 yards north-west of the conservatory and almost concealed under a dense growth of ivy. It measures approximately 8 ft. 10 in. in length, 4 ft. in height, and 1 ft. 8 in. in breadth, and consists of a greenish-grey tough sandstone. Mr. Fisher determined its S.G. to be 1·91 and its weight to amount to 3 tons 2 cwt. Lithologically the rock is precisely similar to portions of the Spilsby Sandstone of Lincolnshire, and a specimen in the Woodwardian Museum from near Claxby is indistinguishable from it. By good luck a small Ammonite occurred in a fragment chipped off by the Rev. E. Conybeare, who met us at Wimpole; and Mr. G. C. Crick, of the British Museum, who has kindly examined it for us, writes that it is "not referable to any species which has hitherto been recorded from Great Britain," but that it "is closely related to *Olcostephanus* (*Craspedites*) *subditus* (Trautschold), which has been recorded from the Spilsby Sandstone of Lincolnshire (Pavlow and Lamplugh, 'Argiles de Speeton,' etc., p. 116, pl. xiii (vi), figs. 5*a*, *b*, *c*)."

The occurrence of many boulders in the Cambridgeshire Boulder-clay from northern sources has been noticed by many observers, and possibly some of the sandstones which are frequently found in it may come from the Lower Greensand beds of Lincolnshire, but, as far as I am aware, no block of such a size from these beds, bearing such a definite proof of its origin, has ever before been

[1] "Palæont. New York," vol. viii, Brachiopoda, ii (1894), pp. 118, 119, pl. li.
[2] "Palæont. Ind.," ser. xiii, Salt Range Fossils, vol. i (1883), p. 495.
[3] "Brit. Foss. Brach.," vol. ii, p. 219, pl. li, fig. 3.
[4] Op. cit., p. 122.

discovered in our area. The outcrop of its parent-bed is about 50 miles distant in a straight line from Old North Road Station. The Boulder-clay, where it was found, is said by Professor Bonney ("Camb. Geol.," p. 49) to be 160 feet thick, as seen in the cutting and well.

From the presence in the Cambridgeshire Boulder-clay of fragments of the Red Chalk and Carstone, and from the general invasion of the outcrops of beds to the south by the materials of beds to the north or north-east, it has been inferred that the direction of movement of the agent of transportation was towards the south; and the occurrence of this boulder of Spilsby Sandstone is strongly in favour of this view. But in spite of this evidence for its support it cannot be said that this theory is completely satisfactory, for it fails to explain the reason of the extremely miscellaneous character of the majority of the non-local rocks in the Boulder-clay, and the distribution of the deposit in relation to the configuration of the country, whether we consider the transporting agent to have been land-ice, icebergs, or an ice-foot.

NOTICES OF MEMOIRS.

Facts and Arguments in favour of an Antarctic Expedition.

IN advocating "The Scientific Advantages of an Antarctic Expedition" before the Royal Society in February last,[1] Dr. John Murray, F.R.S. (now Sir John Murray, K.C.B., F.R.S.), said:—

"From a scientific point of view the advantages to be derived from a well-equipped and well-directed expedition to the Antarctic would, at the present time, be manifold. Every department of natural knowledge would be enriched by systematic observations as to the order in which phenomena coexist and follow each other, in regions of the earth's surface about which we know very little or are wholly ignorant. It is one of the great objects of science to collect observations of the kind here indicated, and it may be safely said that without them we can never arrive at a right understanding of the phenomena by which we are surrounded, even in the habitable parts of the globe.

"Before considering the various orders of phenomena concerning which fuller information is urgently desired, it may be well to point out a fundamental topographical difference between the Arctic and Antarctic. In the northern hemisphere there is a polar sea almost completely surrounded by continental land, and continental conditions for the most part prevail. In the southern hemisphere, on the other hand, there is almost certainly a continent at the South Pole, which is completely surrounded by the ocean, and, in those latitudes, the most simple and extended oceanic conditions on the surface of the globe are encountered."

The author then proceeds to discuss the Meteorology.

[1] Proceedings of the Royal Society, vol. lxii, No. 387, pp. 424–451, Feb. 24, 1898.

"One of the most remarkable features in the meteorology of the globe is the low atmospheric pressure at all seasons in the southern hemisphere south of latitute 45° S., with the accompanying strong westerly and north-westerly winds, large rain and snow fall, all round the South Polar regions. The mean pressure seems to be less than 29 inches, which is much lower than in similar latitudes in the northern hemisphere. Some meteorologists hold that this vast cyclonic system and low-pressure area continues south as far as the pole, the more southerly parts being traversed by secondary cyclones. There are, however, many indications that the extreme South Polar area is occupied by a vast anticyclone, out of which winds blow towards the girdle of low pressure outside the ice-bound region. In support of this view it is pointed out that Ross's barometric observations indicate a gradual rise in the pressure south of the latitude of 75° S., and all Antarctic voyagers agree that when near the ice the majority of the winds are from the south and south-east, and bring clear weather with fall of temperature, while northerly winds bring thick fogs with rise of temperature.

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"There would appear, then, to be good reasons for believing that the region of the South Pole is covered by what may be regarded practically as a great permanent anticyclone with a much wider extension in winter than in summer. It is most likely that the prevailing winds blow out from the pole all the year round towards the surrounding sea, as in the case of Greenland, but, unlike Greenland, this area is probably seldom traversed by cyclonic disturbances.

"But what has been stated only shows how little real knowledge we possess concerning the atmospheric conditions of high southern latitudes. It is certain, however, that even two years' systematic observations within these regions would be of the utmost value for the future of meteorological science."

Referring to the Antarctic ice, Dr. Murray said :—

"From many points of view it would be important to learn something about the condition and distribution of Antarctic sea-ice during the winter months, and especially about the position and motion of the huge table-shaped icebergs at this and other seasons of the year. These flat-topped icebergs, with a thickness of 1,200 or 1,500 feet, with their stratification and their perpendicular cliffs, which rise 150 or 200 feet above and sink 1,100 or 1,400 feet below the level of the sea, form the most striking peculiarity of the Antarctic Ocean. Their form and structure seem clearly to indicate that they were formed on an extended land surface, and have been pushed out over low-lying coasts into the sea.

"Ross sailed for 300 miles along the face of a great ice-barrier from 150 to 200 feet in height, off which he obtained depths of 1,800 and 2,400 feet. This was evidently the sea-front of a great creeping glacier or ice-cap just then in the condition to give birth to the table-shaped icebergs, miles in length, which have been described by every Antarctic voyager.

"All Antarctic land is not, however, surrounded by such inaccessible cliffs of ice, for along the seaward faces of the great mountain ranges of Victoria Land the ice and snow which descend to the sea apparently form cliffs not higher than 10 to 20 feet, and in 1895 Kristensen and Borchgrevink landed at Cape Adare on a pebbly beach, occupied by a penguin rookery, without encountering any land-ice descending to the sea. Where a penguin rookery is situated, we may be quite sure that there is occasionally open water for a considerable portion of the year, and that consequently landing might be effected without much difficulty or delay, and further that a party, once landed, might with safety winter at such a spot, where the penguins would furnish an abundant supply of food and fuel. A properly equipped party of observers situated at a point like this on the Antarctic continent for one or two winters might carry out a most valuable series of scientific observations, make successful excursions towards the interior and bring back valuable information as to the probable thickness of the ice-cap, its temperature at different levels, its rate of accumulation, and its motions, concerning all which points there is much difference of opinion among scientific men."

We come then to the question—"Is there an Antarctic continent? It has already been stated that the form and structure of the Antarctic icebergs indicate that they were built up on, and had flowed over, an extended land surface. As these bergs are floated to the north and broken up in warmer latitudes they distribute over the floor of the ocean a large quantity of glaciated rock fragments and land detritus. These materials were dredged up by the 'Challenger' in considerable quantity, and they show that the rocks over which the Antarctic land-ice moved were gneisses, granites, mica-schists, quartziferous diorites, grained quartzites, sandstones, limestones, and shales. These lithological types are distinctly indicative of continental land, and there can be no doubt about their having been transported from land situated towards the South Pole. D'Urville describes rocky islets off Adélie Land composed of granite and gneiss. Wilkes found on an iceberg, near the same place, boulders of red sandstone and basalt. Borchgrevink and Bull have brought back fragments of mica-schists and other continental rocks from Cape Adare. Dr. Donald brought back from Joinville Island a piece of red jasper or chert containing Radiolaria and sponge spicules. Captain Larsen brought from Seymour Island pieces of fossil coniferous wood, and also fossil shells of *Cucullæa, Cytherea, Cyprina, Teredo,* and *Natica*, having a close resemblance to species known to occur in Lower Tertiary beds in Britain and Patagonia. These fossil remains indicate in these areas a much warmer climate in past times. We are thus in possession of abundant indications that there is a wide extent of continental land within the ice-bound regions of the southern hemisphere.

"It is not likely that any living land-fauna will be discovered on the Antarctic continent away from the penguin rookeries. Still, an Antarctic expedition will certainly throw much light on many

geological problems. Fossil finds in high latitudes are always of special importance. The pieces of fossil wood from Seymour Island can hardly be the only relics of plant life that are likely to be met with in Tertiary and even older systems within the Antarctic. Tertiary, Mesozoic, and Palæozoic forms are tolerably well developed in the Arctic regions, and the occurrence of like forms in the Antarctic regions might be expected to suggest much as to former geographical changes, such as the extension of Antarctica towards the north, and its connection with, or isolation from, the northern continents, and also as to former climatic changes, such as the presence in Pre-Tertiary times of a uniform temperature in the waters of the ocean all over the surface of the globe."

After pointing out the importance of magnetic and pendulum observations, geodetic measurements, tides, and currents, the author referred to the depth of the Antarctic Ocean.

"In regard to the depth of the ocean immediately surrounding the Antarctic continent we have at present very meagre information, and one of the objects of an Antarctic expedition would be to supplement our knowledge by an extensive series of soundings in all directions throughout the Antarctic and Southern Oceans. It would in this way be possible, after a careful consideration of the depths and marine deposits, to trace out approximately the outlines of the Antarctic continent. At the present time we know that Ross obtained depths of 100 to 500 fathoms all over the great bank extending to the east of Victoria Land, and somewhat similar depths have been obtained extending for some distance to the east of Joinville Island. Wilkes sounded in depths of 500 and 800 fathoms about 20 or 30 miles off Adélie Land. The depths found by the 'Challenger' in the neighbourhood of the Antarctic circle were from 1,300 to 1,800 fathoms, and further north the 'Challenger' soundings ranged from 1,260 to 2,600 fathoms. To the south-west of South Georgia, Ross paid out 4,000 fathoms of line without reaching bottom. In the charts of depth which I have constructed I have always placed a deep sea in this position, for it appears to me that Ross, who knew very well how to take soundings, was not likely to have been mistaken in work of this kind.

"The few indications which we thus possess of the depth of the ocean in this part of the world seem to show that there is a gradual shoaling of the ocean from very deep water towards the Antarctic continent, and, so far as we yet know, either from soundings or temperature observations, there are no basins cut off from general oceanic circulation by barriers or ridges, similar to those found towards the Arctic."

Dr. Murray next spoke of the deposits of the Antarctic Ocean.

"The deposits which have been obtained close to the Antarctic continent consist of blue mud, containing glauconite, made up for the most part of detrital matters brought down from the land, but containing a considerable admixture of the remains of pelagic and other organisms. Further to the north there is a very pure diatom ooze, containing a considerable quantity of detrital matter from

icebergs, and a few pelagic foraminifera. This deposit appears to form a zone right round the earth in these latitudes. Still further to the north the deposits pass in deep water, either into a Globigerina ooze, or into a red clay with manganese nodules, sharks' teeth, ear-bones of whales, and the other materials characteristic of that deep-sea deposit. Since these views, however, as to the distribution of deep-sea deposits throughout these high southern latitudes, are founded upon relatively few samples, it cannot be doubted that further samples from different depths in the unexplored regions would yield most interesting information."

The subject of temperature of the Antarctic Ocean was then discussed.

"The mean daily temperature of the surface waters of the Antarctic, as recorded by Ross, to the south of latitude 63° S. in the summer months, varies from 27·3° to 33·6°, and the mean of all his observations is 29·85°. As already stated, his mean for the air during the same period is somewhat lower, being 28·74°. In fact, all observations seem to show that the surface water is warmer than the air during the summer months.

"The 'Challenger' observations of temperature beneath the surface indicate the presence of a stratum of colder water wedged between warmer water at the surface and warm water at the bottom. This wedge-shaped stratum of cold water extends through about 12° of latitude, the thin end terminating about latitude 53° S., its temperature varying from 28° at the southern thick end to 32·5° at the northern thin end, while the temperature of the overlying water ranges from 29° in the south to 38° in the north, and that of the underlying water from 32° to 35°. This must be regarded as the distribution of temperature only during the summer, for it is improbable that during the winter months there is a warmer surface layer.

"In the greater depths of the Antarctic, as far south as the Antarctic circle, the temperature of the water varies between 32° and 35° F., and is not, therefore, very different from the temperature of the deepest bottom water of the tropical regions of the ocean. The presence of this relatively warm water in the deeper parts of the Antarctic Ocean may be explained by a consideration of general oceanic circulation. The warm tropical waters which are driven southwards along the eastern coasts of South America, Africa, and Australia, into the great all-encircling Southern Ocean, there become cooled as they are driven to the east by the strong westerly winds. These waters, on account of their high salinity, can suffer much dilution with Antarctic water, and still be denser than water from these higher latitudes at the same temperature. Here the density observations and the sea-water gases indicate that the cold water found at the greater depths of the ocean probably leaves the surface and sinks towards the bottom in the Southern Ocean, between the latitudes of 45° and 56° S. These deeper, but not necessarily bottom, layers are then drawn slowly northwards towards the tropics, to supply the deficiencies there

produced by evaporation and southward-flowing surface-currents, and these deeper layers of relatively warm water appear likewise to be slowly drawn southwards to the Antarctic area to supply the place of the ice-cold currents of surface water drifted to the north. This warm underlying water is evidently a potent factor in the melting and destruction of the huge table-topped icebergs of the southern hemisphere. While these views as to circulation appear to be well established, still a fuller examination of these waters is most desirable at different seasons of the year, with improved thermometers and sounding machines. Indeed, all deep-sea apparatus has been so much improved as a result of the 'Challenger' explorations, that the labour of taking specific gravity and all other oceanographical observations has been very much lessened."

In speaking of the pelagic life of the Antarctic Ocean, the author mentioned that "In the surface waters of the Antarctic there is a great abundance of diatoms and other marine algæ. These floating banks or meadows form primarily not only the food of pelagic animals, but also the food of the abundant deep-sea life which covers the floor of the ocean in these South Polar regions. Pelagic animals, such as copepods, amphipods, molluscs, and other marine organisms, are also very abundant, although species are fewer than in tropical waters. Some of these animals seem to be nearly, if not quite, identical with those found in high northern latitudes, and they have not been met with in the intervening tropical zones. The numerous species of shelled Pteropods, Foraminifera, Coccoliths, and Rhabdoliths, which exist in the tropical surface waters, gradually disappear as we approach the Antarctic circle, where the shelled Pteropods are represented by a small *Limacina*, and the Foraminifera by only two species of *Globigerina*, which are apparently identical with those in the Arctic Ocean. A peculiarity of the tow-net gatherings made by the 'Challenger' Expedition in high southern latitudes, is the great rarity or absence of the pelagic larvæ of benthonic organisms, and in this respect they agree with similar collections from the cold waters of the Arctic seas. The absence of these larvæ from polar waters may be accounted for by the mode of development of benthonic organisms to be referred to presently. It must be remembered that many of these pelagic organisms pass most of their lives in water of a temperature below 32° F., and it would be most interesting to learn more about their reproduction and general life-history."

As to the benthos life of the Antarctic Ocean, Dr. Murray said:—

"At present we have no information as to the shallow-water fauna of the Antarctic continent; but, judging from what we do know of the off-lying Antarctic islands, there are relatively few species in the shallow waters in depths less than 25 fathoms. On the other hand, life in the deeper waters appears to be exceptionally abundant. The total number of species of Metazoa collected by the 'Challenger' at Kerguelen in depths less than 50 fathoms was about 130, and the number of additional species known from other sources from the shallow waters of the same island is 112, making altogether 242

species, or thirty species less than the number obtained in eight deep hauls with the trawl and dredge in the Kerguelen region of the Southern Ocean, in depths exceeding 1,260 fathoms, in which eight hauls 272 species were obtained. Observations in other regions of the Great Southern Ocean, where there is a low mean annual temperature, also show that the marine fauna around the land in high southern latitudes appears to be very poor in species down to a depth of 25 fathoms, when compared with the number of species present at the mud-line about 100 fathoms, or even at depths of about two miles.

"In 1841 Sir James Clark Ross dredged off the Antarctic continent species which he recognized as the same as he had been in the habit of taking in equally high Northern latitudes, and he suggested that they might have passed from one pole to the other by way of the cold water of the deep sea. Subsequent researches show that, as with pelagic organisms, many of the bottom-living species are identical with, or closely allied to, those of the Arctic regions, and are not represented in the intermediate tropical areas. For instance, the most striking character of the shore-fish fauna of the Southern Ocean is the reappearance of types inhabiting the corresponding latitudes of the northern hemisphere, and not found in the intervening tropical zone. This interruption of continuity in the distribution of shore-fishes is exemplified by species as well as genera, and Dr. Günther enumerates eleven species and twenty-nine genera as illustrating this method of distribution. The genus by which the family Berycidæ is represented in the Southern Temperate Zone (*Trachichthys*) is much more nearly allied to the northern than to the tropical genera. 'As in the Northern Temperate Zone, so in the Southern . . . . the variety of forms is much less than between the tropics. This is especially apparent on comparing the number of species constituting a genus. In this zone, genera composed of more than ten species are the exception, the majority having only from one to five.' . . . . '*Polyprion* is one of those extraordinary instances in which a very specialized form occurs at almost opposite points of the globe, without having left a trace of its previous existence in, or of its passage through, the intermediate space.'

"Speaking of the shore-fishes of the Antarctic Ocean, Günther says: 'The general character of the fauna of Magelhæn's Straits and Kerguelen's Land is extremely similar to that of Iceland and Greenland. As in the Arctic fauna, Chondropterygians are scarce, and represented by *Acanthias vulgaris* and species of *Raja* . . . . As to Acanthopterygians, Cataphracti and Scorpænidæ are represented as in the Arctic fauna, two of the genera (*Sebastes* and *Agonus*) being identical. The Cottidæ are replaced by six genera of Trachinidæ, remarkably similar in form to Arctic types . . . . Gadoid fishes reappear, but are less developed; as usual, they are accompanied by *Myxine*. The reappearance of so specialized a genus as *Lycodes* is most remarkable.'[1]

[1] Günther, "Study of Fishes," pp. 282–290; Edinburgh, 1880.

"These statements with reference to shore-fishes might, with some modifications, be repeated concerning the distribution and character of all classes of marine invertebrates in high northern and high southern latitudes. The 'Challenger' researches show that nearly 250 species taken in high southern latitudes occur also in the northern hemisphere, but are not recorded from the tropical zone. Fifty-four species of seaweeds have also been recorded as showing a similar distribution.[1] Bipolarity in the distribution of marine organisms is a fact, however much naturalists may differ as to its extent and the way in which it has originated.

"All those animals which secrete large quantities of carbonate of lime greatly predominate in the tropics, such as Corals, Decapod Crustacea, Lamellibranchs, and Gasteropods. On the other hand, those animals in which there is a feeble development of carbonate of lime structures predominate in cold polar waters, such as Hydroida, Holothurioidea, Annelida, Amphipoda, Isopoda, and Tunicata. This difference is in direct relation with the temperature of the water in which these organisms live, a much more rapid and abundant precipitate of carbonate of lime being thrown down in warm than in cold water by ammonium carbonate, one of the waste products of organic activity.

"In the Southern and Sub-Antarctic Ocean a large proportion of the Echinoderms develop their young after a fashion which precludes the possibility of a pelagic larval stage. The young are reared within or upon the body of the parent, and have a kind of commensal connection with her till they are large enough to take care of themselves. A similar method of direct development has been observed in eight or nine species of Echinoderms from the cold waters of the northern hemisphere. On the other hand, in temperate and tropical regions the development of a free-swimming larva is so entirely the rule that it is usually described as the normal habit of the Echinodermata. This similarity in the mode of development between Arctic and Antarctic Echinoderms (and the contrast to what takes place in the tropics) holds good also in other classes of Invertebrates, and probably accounts for the absence of free-swimming larvæ of benthonic animals in the surface gatherings in Arctic and Antarctic waters.

"What is urgently required with reference to the biological problems here indicated is a fuller knowledge of the facts, and it cannot be doubted that an Antarctic expedition would bring back collections and observations of the greatest interest to all naturalists and physiologists, and without such information it is impossible to discuss with success the present distribution of organisms over the surface of the globe, or to form a true conception of the antecedent conditions by which that distribution has been brought about."

Dr. Murray concluded his paper as follows:—

"There are many directions in which an Antarctic Expedition would carry out important observations besides those already touched

[1] Murray and Barton, "Phycological Memoirs of the British Museum," part iii; London, 1895.

on in the foregoing statement. From the purely exploratory point of view much might be urged in favour of an Antarctic Expedition at an early date; for the further progress of scientific geography it is essential to have a more exact knowledge of the topography of the Antarctic regions. This would enable a more just conception of the volume relations of land and sea to be formed, and in connection with pendulum observations some hints as to the density of the sub-oceanic crust and the depth of ice and snow on the Antarctic continent might be obtained. In case the above sketch may possibly have created the impression that we really know a great deal about the Antarctic regions, it is necessary to restate that all the general conclusions that have been indicated are largely hypothetical, and to again urge the necessity for a wider and more solid base for generalizations. The results of a successful Antarctic Expedition would mark a great advance in the philosophy—apart from the mere facts—of terrestrial science.

"No thinking person doubts that the Antarctic will be explored. The only questions are: when? and by whom? I should like to see the work undertaken at once, and by the British Navy. I should like to see a sum of £150,000 inserted in the estimates for the purpose. The Government may have sufficient grounds for declining to send forth such an expedition at the present time, but that is no reason why the scientific men of the country should not urge that the exploration of the Antarctic would lead to important additions to knowledge, and that, in the interests of science among English-speaking peoples, the United Kingdom should take not only a large but a leading part in any such exploration."

The Duke of Argyll, Sir J. D. Hooker, Dr. Nansen, Dr. G. Neumayer, Sir Clements Markham, Dr. Alexander Buchan, Sir A. Geikie, Dr. Sclater, Professor D'Arcy Thompson, Admiral Sir W. J. L. Wharton, and others, took part in the discussion which followed.

REVIEWS.

Wachsmuth and Springer's Monograph on Crinoids.

The North American Crinoidea Camerata. By Charles Wachsmuth and Frank Springer. Mem. Mus. Comp. Zool. Harvard, vols. xx and xxi, containing 838 pp. and 83 plates. (Cambridge, U.S.A., May, 1897).

First Notice.

IN the last letter that he wrote me, Charles Wachsmuth repeated a wish already expressed by word of mouth, namely, that in some English publication I should review this grand monograph, then in active preparation. Although, through the kindness of Mr. Alexander Agassiz and Mr. Frank Springer, a copy has been in my hands for a twelvemonth, yet the wish of my departed friend is still unfulfilled. The reasons for delay have been two. The first is the size and importance of the work, coupled with my desire to do it justice. What has taken twenty years to write cannot be digested

and criticized at a week's notice. The second reason is the large amount of personal controversy and criticism of my own writings. Of this so much was made in certain premature reviews published in America, that I could not, at an earlier date, have avoided some remarks in self-defence; and I was unwilling to attack one whose mouth had so recently been sealed by death. The time has at last arrived when I can venture on a satisfactory appreciation of this work, and when argument may meet argument without suspicion of personal bitterness. Therefore, with the kind permission of the Editor of the GEOLOGICAL MAGAZINE, I propose to deal, in a series of notices, with the several sections of the book, directing special attention to facts or opinions first published therein.

The perusal and reperusal of this work has brought to light a few errors. The correction of these, as the pages are passed in review, will, I trust, be ascribed less to a love of censoriousness than to a desire to increase the usefulness of a book that must be the standard of reference for many years to come. Several of these errors are by no means peculiar to Messrs. Wachsmuth and Springer, and it was hardly in their power to discover them.

This memoir consists of three parts:—Introductory, dealing with the history of our knowledge and with terminology; Morphological, dealing with the elements of the crinoid skeleton, and with such internal organs as leave traces in the fossils; Systematic, first dealing with the classification of the Crinoidea, and then describing the North American genera and species referred by the authors to their Order Camerata. Eight plates and a few text-figures elucidate the morphological questions discussed, while seventy-five illustrate the descriptions.

The drawings have been made in pencil by C. R. Keyes, J. L. Ridgway, and A. M. Westergren, and have been reproduced by the Heliotype Printing Co., Boston. There are also a few drawings by G. Liljevall. This mode of illustration is the most satisfactory for palæontological work when fine detail is to be shown. Its peculiar difficulties have been overcome, so far as possible, by the attention of Mr. Westergren. Many of the figures are admirable examples of draughtsmanship; whether they are correct cannot be decided (except in a case to which I shall recur) without comparison with the specimens figured. A thoughtless habit of praising scientific illustrations because they look pretty has made the reputation of many a careless draughtsman. The magnification of the figures should have been stated in all cases where they are not of natural size, not merely in some cases. Information is given as to the collections in which the figured specimens are, but the original locality of each specimen is not indicated. The type-specimens are distinguished, but nothing tells us that several other specimens have been already figured elsewhere. In a few instances it is hard to see how the information that is given can be correct. It is, for example, impossible that figs. 2*a* and 2*b* on pl. xv should represent, as they are said to do, the ventral and dorsal aspects of "the same specimen" of *Gilbertsocrinus dispansus*; even more does this apply

to figs. 2*c* and 2*d*. I would also suggest that figs. 5 and 7 of pl. v are incorrectly described; if they really are in the position stated, then they show a variation of fundamental structure, remarkable not merely in itself but also from the fact that it is not alluded to in the text. While grateful for the numerous figures, so admirably illustrative of specific form, one could have wished to see more drawings of detail on an enlarged scale. The pores of *Batocrinus*, to instance a structure much discussed by our authors, are nowhere adequately figured. Similarly, the representations of the assumed slits or pores in the anal sac of the Fistulate Inadunata are not enough magnified to form evidence worth opposing to the numerous enlarged and detailed figures already published by me as proof that these supposed slits are nothing but deep folds. It is a great boon to have gathered in one volume such charming and, no doubt, trustworthy figures of nearly all the species of North American Camerata; but it may be suggested to future workers that the time has gone by for nothing but pictures of specimens, however exquisite. We want accurate drawings of structure and variations of structure, represented in the most intelligible manner possible. Apparently it is thought undignified or inartistic to put reference letters on the plates illustrating a book of this importance. Such, at any rate, is the custom, with the result that it is often hard to follow descriptions of structure. When an exact drawing of an obscure specimen is given, and in many cases most rightly given, let us at least have an explanatory diagram. Too many of our scientific "ships" are spoiled for want of this "ha'porth of tar"; though this is not always the author's fault. One feature of Messrs. Wachsmuth and Springer's plates is the consistency of orientation: "in illustrating the plates of the calyx, the dorsal view is figured with the anal interradius *up*, and the ventral view with the anal side *down*. Right and left remain the same in both cases." This example should always be followed; and when a specimen is drawn from the side its orientation should invariably be stated.

Let us turn now to the text. The Historical Introduction is of value chiefly for its account of discovery and work in North America. Fourteen hundred crinoid species from that country are now described, but in 1858 only seventy had been defined. In that year remarkable finds were made, and the now famous localities of Burlington, Crawfordsville, Keokuk, and Louisville yielded hundreds of perfect specimens. Troost had already reported, though not published, 86 new species and 16 new genera from Tennessee, but Burlington furnished over 300 species, a greater number than those hitherto known from the whole world. Crinoid-collecting became the rage, while "men of science, anxious to publish the new forms, and fearing they might be preceded by competitors, brought out preliminary descriptions to secure priority for their species. These descriptions, in many cases, were so indefinite that the identification of the species was almost impossible, and this created considerable annoyance and labour to later writers." It is to be feared that the creation of annoyance in this manner has not yet ceased, and that it

is by no means the prerogative of writers on crinoids. Many descriptions issued forty years ago as "preliminary" remain uncompleted to this day. It is pleasant to find that the earlier English authors are not accused of similar bad faith; at the same time, "their descriptions in many cases are so primitive that neither genera nor species can be identified."

The account of the American localities for fossil crinoids, given in this part of the work, is interesting and useful enough to indicate the value there would be in a complete list of such localities with the geological horizon as now ascertained. If the names of the chief collectors could be added, as here, and also a list of the chief species from each locality, so much the better. There are in the Old World, and doubtless in the New, numerous ancient collections of North American crinoids, with somewhat imperfect labels bearing names, both of locality and horizon, which it is hard to identify with names on modern maps or in modern manuals of geology. Nor would it be only on such obscurities that the table we desire would throw light. If drawn up by a competent authority, such as Mr. Springer, it would advance the study of distribution in space and time, an accurate knowledge of which is so necessary to the zoological evolutionist. In this research no help is to be despised. As our authors say in a passage that comes with great weight from practical collectors and palæontologists:

"The trouble is that all our generalizations are necessarily based upon the Crinoids as they are represented *in our museums*, and not upon the Crinoids as they actually existed in geological time, which is a very different thing. It is like trying to reconstruct a book from detached fragments of the chapters, some of them written in hieroglyphics for whose decipherment the key has not yet been found. We are accustomed to speak of the imperfection of the geological record, but it is doubtful if in our practical studies we always bear in mind what this really means. . . . . How much do we actually know of the life represented in the rocks accessible to us? Nearly all the known Silurian Crinoids come from the outcroppings of the strata at two localities in Europe, and three or four in America. The Devonian exposures producing well preserved specimens are even more limited. The Lower Carboniferous collections are better and more widely distributed, but are insignificant after all. Take the Burlington and Keokuk limestones, which in a few localities have produced more Crinoids in number and species than any other formation. They consist of several hundred feet of strata almost entirely composed of the comminuted remains of countless myriads of Crinoids—fragments which are worthless to the Palæontologist. It is only rarely that a thin layer is found in which the calcareous skeletons are preserved well enough for study;—little basins of limited extent, in which, during a period of temporarily quiet waters, the Crinoids lived, died, and were imbedded at sufficient depths to escape the destructive effects of shore action. If the collector happens to be present when one of these colonies is uncovered by the quarrymen, the specimens may be rescued for the

benefit of Science. But it is an even chance that they will be buried in the debris of the quarry, broken up for ballast, or walled up in the foundation of a building, and thus be lost again. Out of the thousands of square miles in which these rocks lie nearest the surface, all the collections that have ever been made represent only the imperfect gleanings of not more than a few acres. If it be supposed that we get, even in this way, a fair representation of the crinoidal life of that period, the answer is that almost every new discovery of 'nests' or 'colonies' of good specimens brings to light new forms, and that species or genera hitherto very rare are often suddenly found within a limited space quite abundantly. In the Upper Coal Measures, to judge from our books and museums, one would suppose that Crinoids were well-nigh extinct. Scarcely a dozen species are known, and most of them only by their lower calyx plates. Yet there are many beds in this formation which extend over hundreds of thousands of square miles from the Missouri Valley far into the Rocky Mountains and tilted up along their flanks, which are completely filled with fragments of Crinoids. Suddenly the collectors at Kansas City, who have studied these rocks for years, discover an abundant deposit of well preserved specimens in a shale so soft that a few minutes' rain dissolves them into unrecognizable fragments." (pp. 167–8.)

The historical account of the European literature will no doubt be of use to American workers, but it would have been of more value to them, and to all of us, had Messrs. Wachsmuth and Springer been in a position to verify their references and quotations instead of copying from De Koninck and W. B. Carpenter. The writings of Agricola and Rosinus may not be accessible to workers in Iowa or New Mexico, but no specialist on Crinoidea can be forgiven for misrepresenting J. S. Miller and Johannes Müller, as do our authors. Let me substantiate this criticism in detail.

Agricola, we are told (p. 11), applied the name "*Encrinus* to the calyx of *Encrinus liliiformis*, at that time the only Crinoid in which a crown had been found in connection with the stem." This is the intensification of an error already bad enough. It was Harenberg who, in 1729, thus misapplied Agricola's term *Encrinus*, which originally bore the same relation to *Pentacrinus* as *Entrochus* bore to *Trochites*, i.e. *Encrinus* meant a series of star-shaped columnals. What Agricola and the rest really did say is set forth in my recent paper, "*Pentacrinus*: a name and its history" (*Natural Science*, vol. xii, pp. 245–256).

The next paragraph says that "Rosinus . . . . was the first writer to show that the Crinoids were not plants, as before then generally supposed, but were closely related to the Asterids." Rosinus was a writer of much merit, but the date of his "De Stellis Marinis quondam nunc Fossilibus Disquisitio" was 1719, whereas Lhuyd had published even more correct views in his "Lithophylacii Britannici Ichnographia," issued at London and Leipzig in 1699 (see *Natural Science*, loc. cit., also vol. xii, pp. 292 and 431). Wachsmuth and Springer's error, copied from De Koninck, was long ago corrected by W. B. Carpenter.

Guettard next receives some praise that is far too faint. The name "Palmier marin" was not his invention; the animal to which it was applied has been more correctly known as *Pentacrinus asteria* than as *P. caput-medusæ*; there are three misprints in the reference to his paper.

Blumenbach (the date of whose "Handbuch der Naturgeschichte," Ed. 1, is 1779, not 1780) obtains "the credit of having been the first writer who ranked them [crinoids] with the Asteroids and Ophiurids among the order 'Vermes crustacei,' which corresponds approximately to our present Echinoderms." He may have been the first *post-Linnæan* writer to do this; but he was only following Llhuyd in both arrangement and terminology. Moreover, in the edition of the "Handbuch" cited by our authors, Blumenbach referred the Echinoderms to 'Cartilaginea,' associating the crinoids with various Hydrozoa. It was not until 1788 that he placed them under 'Crustacea.'

J. S. Miller's definition of a crinoid is turned into nonsense on p. 12. Miller wrote as follows, but Wachsmuth and Springer have quoted only the italicized words: "*An animal with a round, oval, or angular column, composed of numerous articulating joints*, supporting at its summit a series of plates or joints *forming a cup-like body containing the viscera, from whose upper rim proceed five articulated* arms, dividing into tentaculated *fingers*, more or less numerous, surrounding the aperture of the mouth, situated in the centre of a plated integument, which extends over the abdominal cavity, and is capable of being contracted into a conic or proboscal shape." The omissions can scarcely be intentional.

On p. 14 "Heisinger (1837)" no doubt refers to Hisinger's "Lethæa suecica," which was published in that year, and not to Heusinger, who also was an early writer on crinoids.

On the same page it is said that Joh. Müller's paper "Ueber den Bau des Pentacrinus caput-medusæ" appeared in 1840. The first part of it was read in that year, but none was published till 1843. In this paper Müller wrote as an anatomist rather than as a systematist, and it is not easy to understand what his precise views as to the classification may have been. Probably he wrote thus of set purpose, recognizing that the time for a formal classification of crinoids had not arrived, and intending only to give names to certain plans of structure. Nevertheless, my interpretation of Müller is so different from that of Messrs. Wachsmuth and Springer that I can only suppose they have not referred to the original paper, incredible though such an inference may seem. "Müller," they write, "divided the Crinoids into three great groups: the '*Crinoidea Articulata*,' the '*Crinoidea Tessellata*,' and the '*Crinoidea Costata*.'" And again: "The Tessellata were subdivided by Müller into two groups: Crinoidea *with arms*, and Crinoidea *without arms*. To the former he referred all true Crinoids and the Cystid genus *Caryocrinus*. . . . . The *armless* Crinoids comprise the 'Pentremites' (Blastoidea) and 'Sphæronites' (Cystidea)."

Instead of criticizing these statements in detail I will contrast

with them my interpretation of Müller's intentions. Müller's 'Crinoidea' included all Pelmatozoa then known. His first division was into those with arms and those without, the former group being the 'Crinoidea brachiata' of writers who preferred a Latin terminology, and the latter including 'Pentremites' and 'Sphæronites.' Among crinoids with arms, the stalked forms were always distinguished from the unstalked; but it is not clear that Müller intended this as a prime classificatory division, although the point should not be omitted from any account of his views. Apart from this he noted, not three, but five divisions in the Crinoidea brachiata, viz.: (1) the Articulata, both stalked, as Pentacrinidæ, and unstalked, as Antedonidæ; (2) the Tessellata, both stalked, as most Palæozoic crinoids, and unstalked, as *Marsupites*; (3) the Costata, unstalked only, and not to be described as a "great group," since it included only the small genus *Saccocoma*; (4) the Testacea, erected for the reception of *Haplocrinus mespiliformis*, and defined thus: cup and tegmen form a firm, connected test, with five ambulacra running up to the mouth; (5) *Holopus*, "eine ganz eigenthümliche Abtheilung der festsitzenden Crinoiden" (p. 210), with sessile cup and, apparently, no anus (p. 229). "The stalked crinoids without arms," writes Müller (p. 229), "form two Families. Both are most probably [unlike the Tessellata] provided with distinct mouth and anus." The first Family is further distinguished from Tessellata by having a star-shaped arrangement of ambulacra on the ventral surface of the calyx: "these are the Pentremites." The second Family, which may be described in Müller's words as "Die Tessellata dieser Abtheilung, ohne Stern von Tentakelfelder," are the Sphæronites "with their genera as established by Mr. von Buch (1840)." It was probably this phrase "Die Tessellata dieser Abtheilung" that led Messrs. Wachsmuth and Springer to suppose that Müller really meant to class the Cystidea in the Tessellata; surely he merely meant to imply that they followed in this one respect the 'tessellate' type of structure. In any case the phrase shows that he did not place the Blastoidea with the Tessellata; in fact, on the previous page he compares them, much in the same way, with the Testacea.

It results from the above that the statement on p. 23, that Zittel in 1879 followed Müller in his classification, is also incorrect. For Zittel really did divide the Crinoidea brachiata, or Eucrinoidea as he called them, into three suborders, merging *Holopus* and the Testacea in the Articulata.

I do not know what is meant by "Roemer's classical memoir on the Cystidea," but everybody knows his memoir on the Blastoidea, and knows that it was published in 1851, not in 1855 as would follow from the remarks on p. 17 of the present monograph. The reference to Pictet's Paléontologie on the same page should not be "Tom. v" but "2e edition, tom. iv."

The account of the successive classifications proposed by Wachsmuth and Springer themselves is clear, and will be welcomed by many who have not mastered all the previous

writings of these authors. But in the account of P. H. Carpenter's views is a curious omission. The division of the Crinoidea by Wachsmuth and Springer into Palæocrinoidea and Stomatocrinoidea was accepted by Carpenter and Etheridge, jun., in 1881 (Ann. Mag. Nat. Hist., [5,] vii, 281–298); the latter authors, however, laid more stress on the asymmetry of the posterior interradius in Palæocrinoidea than on the condition of the tegmen, and therefore suggested the names Irregularia and Regularia.

It is personally gratifying to gather from this history that the first rejection of the division into Palæocrinoidea and Neocrinoidea must have been independently and synchronously published by these eminent American authorities and by myself (February, 1889); further, that in applying the logical consequences of the tegminal structure of *Tuxocrinus* to all Crinoidea, I actually preceded them by half a year (April, 1890). No one will suffer from the absence of all allusion to this in the present monograph, which certainly does not err in the direction of underestimating any contributions that I have so far been able to make to our knowledge of the Crinoidea.

Such errors as have been pointed out do not materially detract from the value of the monograph, and we can readily forgive a few such slips when we remember the age and ill-health with which the senior author had to struggle, and the constant pressure of other occupation that must have made his colleague's revision of the proofs a task of no ordinary difficulty. These circumstances will, I hope, always be borne in mind by any who read the present or future chapters of this review. F. A. Bather.

(*To be continued.*)

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 20, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "Note on an Ebbing and Flowing Well, at Newton Nottage (Glamorganshire)." By H. G. Madan, Esq., M.A., F.C.S. (Communicated by A. Strahan, Esq., M.A., F.G.S.)

This well lies in a direct line drawn north and south from the church of Newton Nottage to the sea, about 80 yards south of the church and 500 yards from the sea. Sand-hills about 20 or 30 feet high lie between it and the sea. A range of Carboniferous Limestone cliffs runs east and west to the north of the church, while the same formation crops out in the sea at half-tide level. Between the two there is a band of Keuper conglomerate covered in one place at least by 7 feet of brown loamy clay with pebbles. At the shore-junction of conglomerate and limestone numerous springs occur, and it is in the conglomerate that the well is sunk, its bottom being 8 feet above ordnance datum.

A series of about forty observations made at intervals of an hour (and in many cases at the intermediate half-hours) during three

consecutive days, enables the author to construct a curve showing the relationship existing between the rise and fall of the tide on the coast and that of the water in the well. The result is to establish the existence of a wave in the well of the same frequency as the tidal wave, but delayed, or with an establishment of, three hours (*plus* or *minus* a few minutes).

The analyses of water taken from the well at its highest and lowest show no difference, so that no sea-water enters the well directly. On the other hand, the slight brackishness of the water appears to prove the diffusion of a small amount of salt water into the well.

2. "*Petalocrinus.*" By F. A. Bather, Esq., M.A., F.G.S.

Certain curious fan-like objects, obviously echinodermal, have for a long time been preserved in the Riks-Museum at Stockholm, but their significance was first definitely ascertained when similar fossils were found in Iowa, and brought to England by Mrs. Davidson. The latter were described by Mr. Stuart Weller in a paper entitled "*Petalocrinus mirabilis* (n.sp.), and a New American Fauna"; and the former, with fresh material obtained by Mr. Weller from various American localities, are the subject of the present communication.

The Silurian crinoid genus *Petalocrinus*, Weller, is discussed, on the evidence of all the original material from Iowa and of the further material above mentioned. The replacement of the original material of the Iowan fossils by silica has taken place only in certain parts, forming a number of siliceous boxes, as it were, which are either hollow or more or less filled with chalcedony or cryptocrystalline silica. They are therefore neither casts nor impressions, and details of structure are frequently destroyed.

Petalocrinus is shown to have a dicyclic base—not monocyclic, as originally described. The structure of the tegmen is shown to be that of the Cyathocrinoidea. The arm-fans characteristic of the genus are proved to have been formed by fusion of the branches of an arm of Cyathocrinid type. In them, description is given for the first time of axial canals, covering-plates, the articular facet, and various minor structures. The species *P. major*, Weller, is shown to be an *Omphyma*; but *P. mirabilis*, Weller, the genotype, is redescribed, and with it five new species—two from Iowa; three, as well as a possible mutation of one of them, from Gotland. A family Petalocrinidæ, descended from the Cyathocrinidæ, probably by way of *Arachnocrinus*, is founded for the reception of this genus.

3. "On the Origin of the Auriferous Conglomerates of the Gold Coast Colony (West Africa)." By Thomas B. F. Sam, Esq., C.E. (Communicated by J. Logan Lobley, Esq., F.G.S.)

This paper gives an account of a recent journey from Adjah Bippo to the Ankobra Junction in the Gold Coast Colony. A range of clay-slate hills is succeeded for six miles by flat ground in which diorite was found, and that by a lofty hill in which clay-slate dipping east occurs. The Teberibie range with reefs of conglomerate, and a second range with similar reefs, were crossed.

Gold-bearing alluvia are briefly described, and the gold is supposed to have come from the hills. The Adjah Bippo, Takwa, and Teberibie formations are considered to be part of a syncline. Some conclusions are drawn as to the method of formation and probable auriferous character of the rocks.

II.—May 4, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read :—

1. "The Carboniferous Limestone of the Country around Llandudno." By G. H. Morton, Esq., F.G.S.

Llandudno is so well known and frequently visited, that the Carboniferous Limestone and the subdivisions into which it is divided by clear lithological characters may be more easily examined there than at any other similar locality. The subdivisions of "Lower Brown," "Middle White," and "Upper Grey," along the broad belt of limestone from Llanymynech to Prestatyn, and around the Vale of Clwyd, Abergele, and Llandulas, have been so frequently described in the Proceedings of the Liverpool Geological Society that it is unnecessary to give any general description of them. At Llandudno the precipitous Great Orme's Head presents fine sections of the Carboniferous Limestone and the subdivisions referred to, and may be easily examined (with the aid of the appended geological map), in a continuous series of cliffs, ridges, and quarries. The entire succession is, however, not perfect, for the highest beds of the "Upper Grey Limestone" have been denuded, and at the Little Orme's Head the subdivision is altogether absent.

Copper-lodes on the Great Orme's Head appear to have been worked by the Romans, and again in recent years until abandoned fully thirty years ago. Some of the lodes are faults, but little can be ascertained about them now, and only two or three are faults with any appreciable amount of dislocation. It is to the undulation of the limestone that the ever-varying dip of the beds is attributed.

Numerous fossils occur in the "Upper Grey Limestone," and a few are peculiar to the subdivision and the locality, but of these only a single specimen of each has been found. *Productus margaritaceus* is abundant, though only an occasional species in other localities, and not found at a lower horizon anywhere else in North Wales. Other species, such as *Orthis Michelini*, formerly supposed to be peculiar to the "Upper Grey Limestone," have been found at the base of the "Middle White Limestone," at the Flagstaff Quarry on the Marine Drive, near the Happy Valley.

The dolomitization of the Carboniferous Limestone is remarkable, and almost peculiar to that around Llandudno, though it also occurs at Penmon in Anglesey. The "Lower Brown Limestone" has been almost entirely converted into dolomite, and portions of the overlying subdivisions. The filling of the faults has often been changed into dolomite, and the alteration of the Limestone has generally been very capricious: the author's opinion being that the change took place after the dislocation of the strata in post-Triassic times.

To illustrate Miss G. L. Elles's paper on the Graptolite-Fauna of the Skiddaw Slates. (See p. 287.)

Lake District.	S. Wales.	S. Scotland.	Canada.	Sweden (Scania), after Tullberg.
(Borrowdale Volcanic Series.)				
Upper Skiddaw Slates.				Lower part of *Dicellograptus*-Skiffer. — Higher Zones of *Dicellograptus*-shales.
(*a*) Millburn Beds.	? Llandeilo.			
(*b*) Ellergill Beds, with *Diplograptus*.	Llanvirn.	? Lower parts of Barr Series.		Zone (n) *Glossograptus*. Zone (o) *D. gemmus*.
Middle Skiddaw Slates.				*Phyllograptus*-Skiffer. — Zone of *Phyllograptus* cf. *typus* (Hall).
(*a*) Upper *Tetragraptus*-beds.	Upper Arenig.	Bennane Shales.	Quebec Group.	
(*b*) *Dichograptus*-beds.	Middle Arenig.			*Orthoceras*-limestone.
(*c*) Lower *Tetragraptus*-beds.	Lower Arenig.			*Tetragraptus*-beds.
Lower Skiddaw Slates.				
(*a*) *Bryograptus*-beds.	Tremadoc.			*Ceratopyge*-beds.
(*b*) ?	? *Lingula*-flags.			

Table showing the relationships of the divisions of the Skiddaw Slates with the other rocks of these areas.

2. "The Graptolite-Fauna of the Skiddaw Slates." By Miss G. L. Elles. (Communicated by J. E. Marr, Esq., M.A., F.R.S., F.G.S.)

This paper deals not only with the collections of the author, but with the Dover Collection and others preserved in the Woodwardian Museum, with the collections of Professor H. A. Nicholson, Mr. Postlethwaite, and that of the Keswick Museum of Natural History. An account of the literature, both stratigraphical and palæontological, of the Skiddaw Slates is given, followed by a list of all the graptolites known from the beds. This list comprises 22 genera and 59 species.

In the ensuing description all the known genera and species are noted, and corrections and additions made to existing knowledge concerning the diagnosis, structure, and development of many of them.

The following seven species, new to this country—*Bryograptus ramosus* (Brög.), *Clonograptus tenellus* (Linn.), *Trochograptus diffusus* (Holm), *Pterograptus* (Holm) sp., *Didymograptus gracilis* (Törnq.), *Azygograptus suecicus* (Mbg.), *Diplograptus appendiculatus* (Törnq. MS.)—and ten new species and varieties are described.

A table showing the distribution of the Skiddaw graptolites in the Arenig rocks of Great Britain, in the *Phyllograptus*-Skiffer, etc., of Sweden, and the Quebec Group of Canada is given, and the accompanying (contracted) table (p. 286) expresses the relationships of the divisions of the Skiddaw Slates with the rocks of these areas.

In conclusion, the author is struck with the remarkable resemblances existing between the species of various genera; these can be so easily explained by supposing that the forms in question are the results of development along certain lines, that she offers the suggestion that this is their real origin. In dealing with the phylogeny, she divides these graptolites into two groups—

(1) Those derived from a *Bryograptus*-form.
(2) Those derived from a *Clonograptus*-form.

To the first group belong 15 named graptolites from the Skiddaw Slates and 4 species from other localities; and to the second 12 Skiddaw species and 2 others.

CORRESPONDENCE.

THE LLANBERIS UNCONFORMITY.

Sir,—As my name has figured much in your pages for the last two months permit me to say that I have no intention of replying to Mr. Blake's "Revindication of the Llanberis Unconformity." My chief reasons for adopting this course are: (1) It would be necessary for me to investigate on the ground all statements which rest only on his authority, because hitherto I have so often found that what he deems facts appear to me to be fancies. For this task I have now no time, being tied much more closely to London than was formerly the case, so that my short vacations are devoted to work which offers greater attractions. (2) Controversy with

Mr. Blake is endless. What is one year "a crucial test" and "a decisive proof" is thrown overboard in another as absolutely unimportant, nay, as a good riddance (compare Q.J.G.S., 1888, p. 284, with id., 1892, p. 244, and this Magazine, 1891, p. 487). It is like seeking to tie down Proteus. Prove him wrong, that point is dropped and another is started: "Primo avulso non deficit alter Plumbeus." I will therefore merely say that some of the slips or changes of opinion, which he attributes to me, exist only in his own imagination, and that in regard to one or two points where I have altered my mind (and have never made any secret of it as he seems to insinuate) I am not ashamed to draw fresh inferences when new facts have been discovered. Thus I have had to unlearn much that I was taught in my younger days about crystalline and metamorphic rocks by those to whom I looked up. So I am content (as I believe Miss Raisin is) to leave Mr. Blake apparently in possession of the field, unless it should happen that some former pupil, anxious to flesh a maiden sword, should crave for a subject, in which case I promise to recommend to him the "Revindication of the Llanberis Unconformity."

T. G. Bonney.

University College, London.
May, 1898.

OBITUARY.

Edward Wilson, F.G.S.—We have just received (May 23rd) the sad intelligence of the loss of our highly esteemed fellow-worker in Geology, Edward Wilson, F.G.S., for fourteen years the untiring Curator of the Bristol Museum, whose published papers have appeared in the Quarterly Journal of the Geological Society, the Geological Magazine, and other periodicals. In 1888 he received the award of the Murchison Fund from the Council of the Geological Society (of which Society he had been elected a Fellow in 1872). Mr. Wilson's published papers date back for thirty years, and deal with the Red Marls, the Keuper and Bunter Beds, the Rhætic, and Lias. He has also published papers upon the Liassic Gasteropoda, etc. At the time of his death he was investigating the Uphill Cave Deposits, near Weston-super-Mare. He passed away, after three weeks illness, on May 21st, 1898, in his 49th year.

MISCELLANEOUS.

Geological Survey Appointments.—The vacancy caused by the resignation of Mr. W. W. Watts has been filled by the appointment of Mr. W. Pollard, M.A., D.Sc., who joins as an Assistant Geologist in the Petrographical Department; and that caused by the retirement of Mr. De Rance has been filled by Mr. C. B. Wedd, B.A., as Assistant Geologist. In Ireland, the petrographical work will be carried on by Mr. H. J. Seymour, B.A., who succeeds as Assistant Geologist to the post left vacant by the resignation of Professor Sollas.